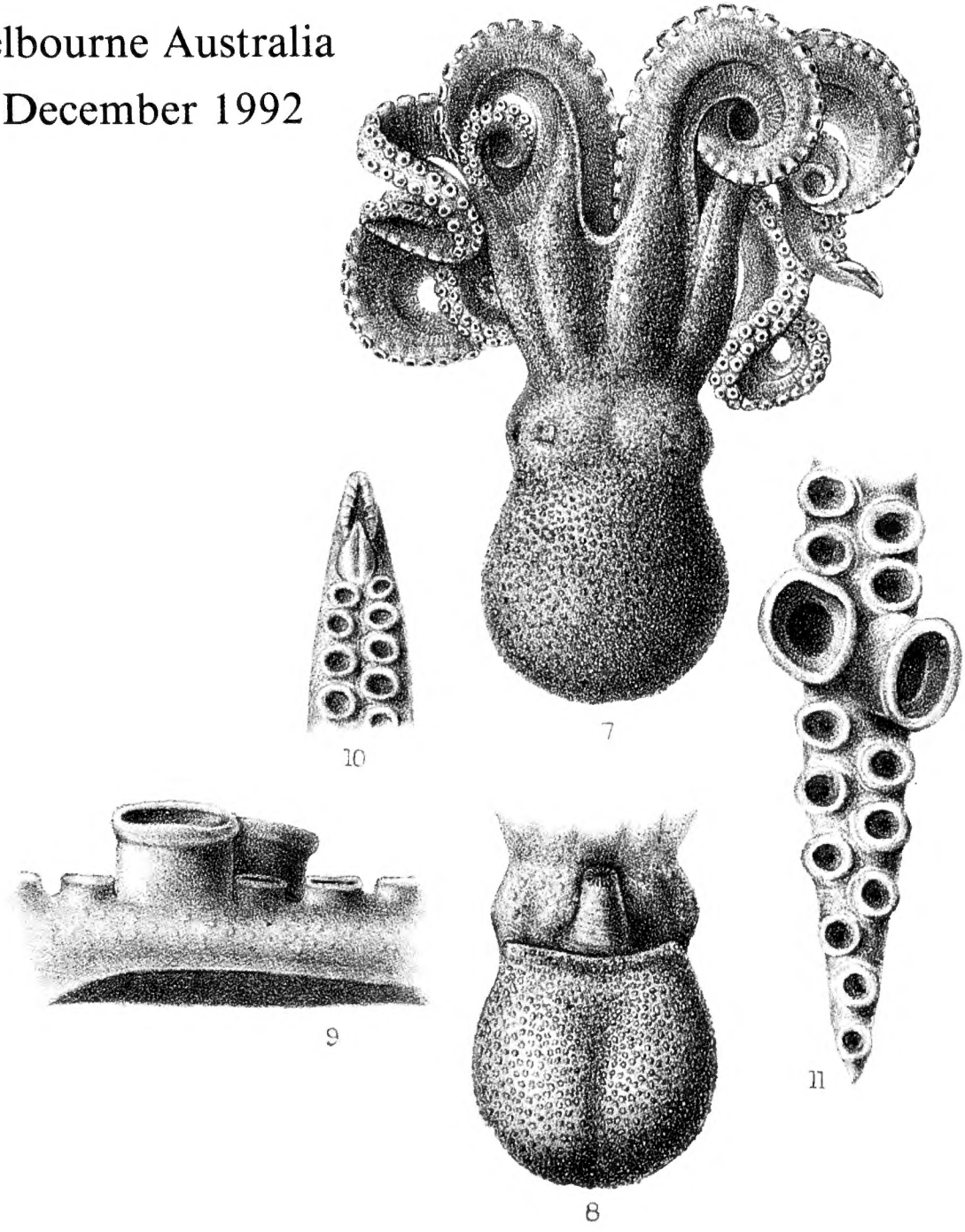
Memoirs of the

Volume 53
Number 2

Museum of Victoria

Melbourne Australia
31 December 1992



Cover: Part of a plate from Edgar A. Smith's report on the molluces collected by the "Southern Cross" during its expedition to Antarctica from 1898 to 1900. The figures are of *Octopus campbelli* (Smith), an octopus collected at Campbell Island, New Zealand. The specimen is redescribed in this volume by Timothy Stranks and Mark Norman, and compared with similar species from New Zealand and Australia.

ISSN 0814-1827

MEMOIRS

of the
MUSEUM OF VICTORIA

MELBOURNE AUSTRALIA

Memoir 53
Number 2
31 December 1992

PUBLISHED BY ORDER OF THE COUNCIL

Printed by Brown Prior Anderson Pty Ltd Burwood Victoria

Instructions to Authors

The Museum of Victoria was formed in 1983 by the merger of the National Museum of Victoria (established in 1854) and the Science Museum of Victoria (established in 1879). Among the Museum's objectives are scholarship and education in the fields of natural history, science and technology, and history of human society. The Museum of Victoria publishes three scientific serials to further these objectives, *Memoirs of the Museum of Victoria* (until 1983 *Memoirs of the National Museum of Victoria*), *Memoirs of the Museum of Victoria (Anthropology and History)*, and *Occasional Papers from the Museum of Victoria.*

The two *Memoirs* series publishes papers on original research in the natural sciences on one hand, and anthropology and history on the other, pertinent to Victoria and/or the Museum's collections. All contributions are assessed by independent referees before publication.

The *Occasional Papers* are research documents of sufficient importance to be preserved but which are not appropriate for primary scientific publication. Papers are factual rather than interpretative studies, may be of special local interest, or may be longer than a normal scientific paper. Contributions will be refereed if appropriate.

Two copies of the manuscript with accompanying plates and figures should be submitted to the Scientific Editor, Museum of Victoria, Swanston Street, Melbourne, Victoria 3000. Authors should consult a recent volume of the *Memoirs* to aquaint themselves with format.

Manuscripts must be typed on A4 paper, double-spaced, on one side of the paper and with ample margins. Except for short papers (less than 10 manuscript pages) presentation of the final manuscript on word-processor floppy disks is essential. Papers should be arranged as follows: title (including higher classification of zoological taxa); authors' names and addresses; abstract; contents (only if the paper is very long); introduction and main text; acknowledgements; references; index (only if very long); and tables. Captions to text figures and plates must be attached to the manuscript as final pages. Underlining in the text should be restricted to generic and specific names. Measurements must be in the metric system (SI units).

References should be listed alphabetically at the end of the manuscript. Journal titles must be in full. References to books must give the year of publication, edition, name of publisher and city of publication.

In taxonomic papers synonymies should be of the short form: taxon, author, year, pages, figures. A period and dash must separate taxon and author except in the case of reference to the original description.

Photographs must have clear definition and may be submitted as either glossy or flat prints at the actual size for reproduction. Line drawings for text-figures should be in black ink on white card or drawing film. Maximum full-page size is 140 mm wide by 193 mm; single column width is 67 mm. Clear lettering must be inserted. Original drawings up to twice final size are acceptable.

CONTENTS

Memoirs of the Museum of Victoria 53(2): 137–220 (1992)

THE PSOCOPTERA (INSECTA) OF WILSONS PROMONTORY NATIONAL PARK, VICTORIA, AUSTRALIA

By E. R. Schmidt and I. W. B. Thornton

Department of Zoology, La Trobe University, Bundoora, Victoria 3083, Australia

Abstract

Schmidt, E.R. and Thornton, I.W.B., 1992. The Psocoptera (Insecta) of Wilsons Promontory National Park, Victoria, Australia. *Memoirs of the Museum of Victoria* 53: 137–220.

Psocoptera (psocids) were collected by beating from a wide range of habitat associations at Wilsons Promontory National Park, Victoria. Eleven different habitats were regularly sampled over a 13-month period during 1985-1986 and additional habitats were extensively sampled at other times. Sixty-eight species were collected, representing 25 genera in 11 families. Twenty-four species are newly described and further descriptions provided for nine species. The fauna is richer than that found in surveys of other regions of south-eastern Australia but the α diversity index (α = 10.74) is similar to that found at Muogamarra Nature Reserve, near Sydney, NSW. The large number of plant associations at Wilsons Promontory appears to be the most likely explanation for the relative richness of the psocopteran fauna.

Keywords: Psocoptera; Wilsons Promontory; Bass Strait zoogeography, faunal diversity.

Introduction

The Psocoptera (psocids) is one of the smaller and lesser-known insect orders. About 3500 species of 36 families are known and the insects occur commonly in all zoogeographical regions. Several species are cosmopolitan and others have wide tropical ranges. Many species, however, have limited distributions giving rise to regional faunas. Several islands and archipelagos of the inner and outer Melanesian arcs in the west and south-west Pacific, New Guinea and adjacent Indonesian islands contain such faunas, which recently have prompted inferences concerning systematics and biogeographical distributions (Smithers and Thornton, 1981 and references therein, 1990; Thornton et al., 1988; Thornton, 1989 and references therein).

Surveys of the Muogamarra Nature Reserve, near Sydney (Smithers, 1977), and of South Australia (Smithers, 1984) indicated that the temperate Australian psocopteran fauna is diverse and little known. Earlier records from Victoria are predominantly by New (1973a, 1973b, 1974a, 1974b) and Thornton and New (1977). More recently a survey of two isolated inland regions of Victoria, The Grampians and Mt Arapiles (Endersby et al., 1990) yielded 32 species, raising the known species in Victoria to 61. Investigations of the fauna of the Bass Strait islands (Cole et al., 1989) and the Otway Ranges (Thomas, 1986) have been made and the fauna of Tasmania is currently being studied. A survey of the fauna of south-eastern Australian highland areas was made in early 1990, and is now being analysed.

Mackerras (1970) regarded the insect fauna of south-eastern Australia as comprising predominantly the southern element of Australia's fauna, some groups showing affinities with New Zealand, New Caledonia, southern cool temperate South America and (to a lesser extent) South Africa. These disjunctions appear to reflect historical Gondwanan connections via Antarctica.

Pleistocene lowering of sea level was sufficient to expose a land bridge, the Bassian Rise, connecting southern Victoria via Flinders Island to Tasmania (Blom, 1988; Rawlinson, 1974) (Map A). Changes in world climate, associated vegetation shifts and intermittent land connections probably occurred often, causing repeated isolation and fusion of habitats conducive to speciation. Thus, south-eastern Australia, particularly Tasmania and the Bass Strait region, is an area well suited for investigations of patterns of distribution and evolution of Psocoptera.

Thirty-one described species are known from mainland Tasmania (Edwards, 1950; Hickman, 1934; Smithers, 1979) and 33 from the Bass Strait Islands (Cole et al., 1989; New, 1971). The relationships of the fauna of the Bass Strait islands to those of Tasmania and southern Victoria were assessed by Cole et al. (1989) but several species remain to be described from this survey. In addition, current studies of the faunas of both mainland Tasmania and the areas of southern Victoria mentioned above have

revealed a number of undescribed species in the south-eastern Australian fauna. As a further contribution to our knowledge of Psocoptera in the Bass Strait region, a study was made of the psocopteran fauna of Wilsons Promontory National Park based on a systematic survey over thirteen months.

Study area

Wilsons Promontory, a hilly peninsula 235 km south-east of Melbourne, Victoria (39°S, 146°20′E), is the most southerly part of the Australian mainland (Map A). It was permanently reserved as a national park in 1905 and later additions increased the area of the park to its present size of almost 49 000 hectares. The land rises from sea level to 754 m at the highest peak, Mt Latrobe, and there are a number of other hills of about this height.

Mean annual rainfall at Tidal River is 1080 mm, the maximum occurring in June, the minimum in January. The wettest months are May to August, the driest December to March. Temperatures are moderate and frosts rare. The prevailing wind is from the west in all months except July (north-west), August (north-west and west) and December (west and north-east). Eastern and south-eastern aspects are characterized by lower evapotranspiration rates than western and northwestern aspects. Mean monthly wind speeds show no seasonal trends, varying from 20 to 30 km h^{-1}, similar to those of other exposed coastal locations in southern Australia (Parsons, 1966).

Bass Strait has existed since the early Tertiary. During the Pleistocene the granite peaks of Wilsons Promontory formed part of a range of mountains, the Bassian Rise, linking Tasmania with the mainland through the Hogan, Curtis and Kent Groups of islands to Flinders and Cape Barren Islands (Jennings, 1959) (Map A).

Five major world glacial phases have been recognised since the Pleistocene. In the last three of these (the Illinoian, Early Wisconsin and Late Wisconsin) sea levels fell below minus 80 m, exposing the Bassian Rise (maximum depth 55 m) and the western land bridge extending from Tasmania through King Island to the Mornington Peninsula (maximum depth 67 m) (Blom, 1988). At the peak of the last glacial phase (18 000–20 000 years ago) the sea lay 132–150 m below the present level. Since then the sea level has risen and the present coastline was attained about 5 000 years ago. Western Bass Strait was breached 11 800 years ago and the Bassian Rise of eastern Bass Strait 8 700 years ago (Blom, 1988). The establishment of the land bridges had facilitated faunal interchange between the mainland and Tasmania during periods when the climate was colder than at present (Blom, 1988; Cole et al., 1989; Rawlinson, 1974) and when these were breached the Tasmanian fauna was able to develop in relative isolation. Rises in sea level during the Pleistocene (approximately 120 000 years ago) turned Wilsons Promontory into an island. As a result of the action of wind and tides sand has gradually built up the gap between the island and the mainland, forming the Yanakie Isthmus (Anon, 1984; Edgecombe, 1985).

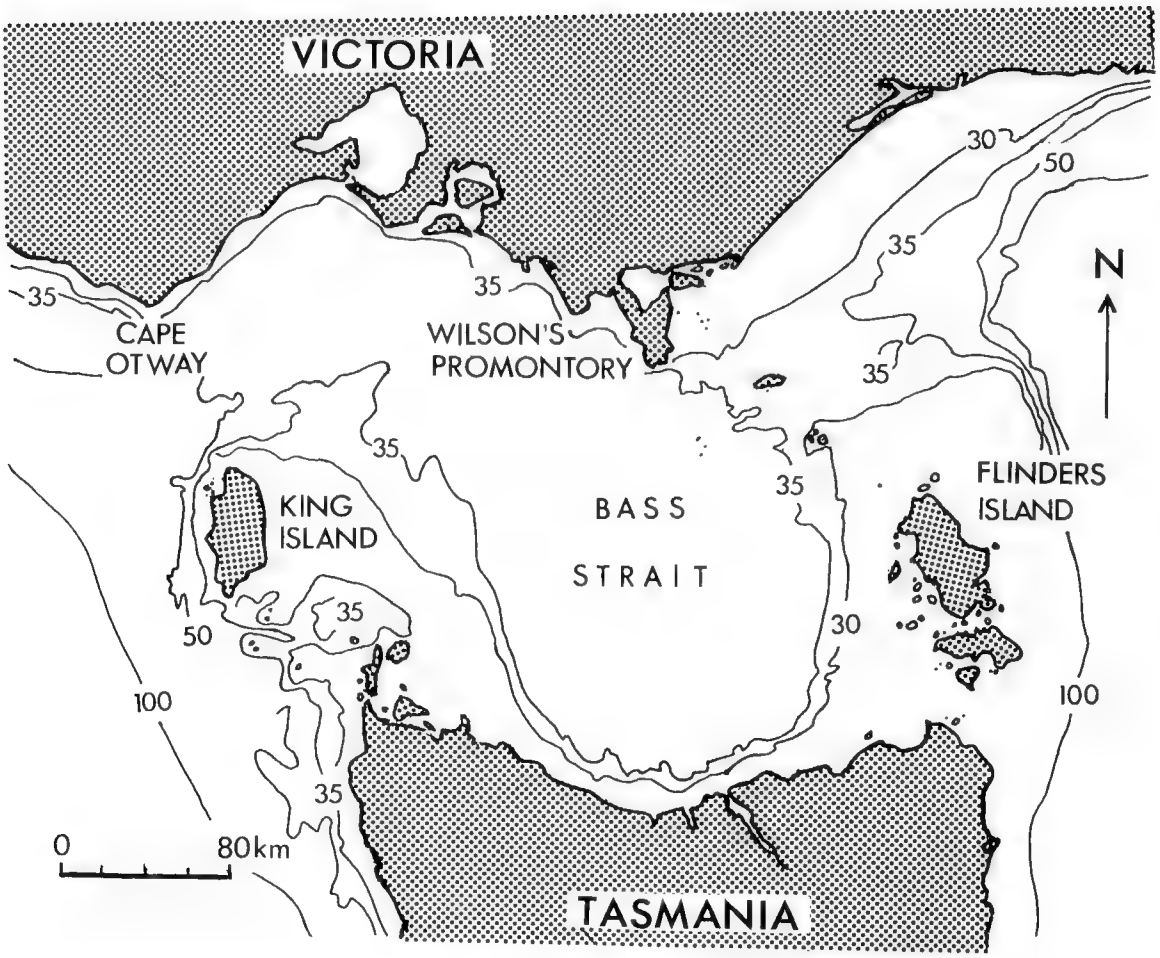
Reed (1959) has summarised the geology of Wilsons Promontory. The promontory is composed of two separate units: granite and recent deposits. Granite outcrops over most of the National Park and forms the bedrock of the area. The rock is a uniform grey, coarse-grained, well-jointed porphyritic granite containing felspar crystals of Devonian age. Recent deposits are confined to small areas of sand dunes, alluvial formations and swamps. Sand dunes are better developed on the western side than on the east, where in general they are restricted to one or two fairly low ridges running parallel to the coast (e.g., Five Mile Beach, Map B). On the western side, sand dunes up to 15 m high occur on the flat and low-lying swampy areas at the heads of bays and inlets where wind-blown sand has been able to accumulate (e.g., at the heads of the neighbouring Leonard, Norman and Oberon Bays). Near the south end of Darby Beach and on parts of the Yanakie grasslands, thick beds of Pleistocene dune limestone lie under recent sand dunes. Alluvial and swamp deposits, consisting mainly of detritus derived from the weathering of granite, extend from the foot of the hills to the coast forming areas of flat, low-lying and usually badly-drained country.

As a result of extensive analysis of aerial photographs, Smith (1978) described 27 different vegetation units in Wilsons Promontory. He described the promontory as constituting the "meeting ground" and often the distributional boundary of plant species from many parts of south-eastern Australia, thus having floristic links with western Victoria, Tasmania and East Gippsland.

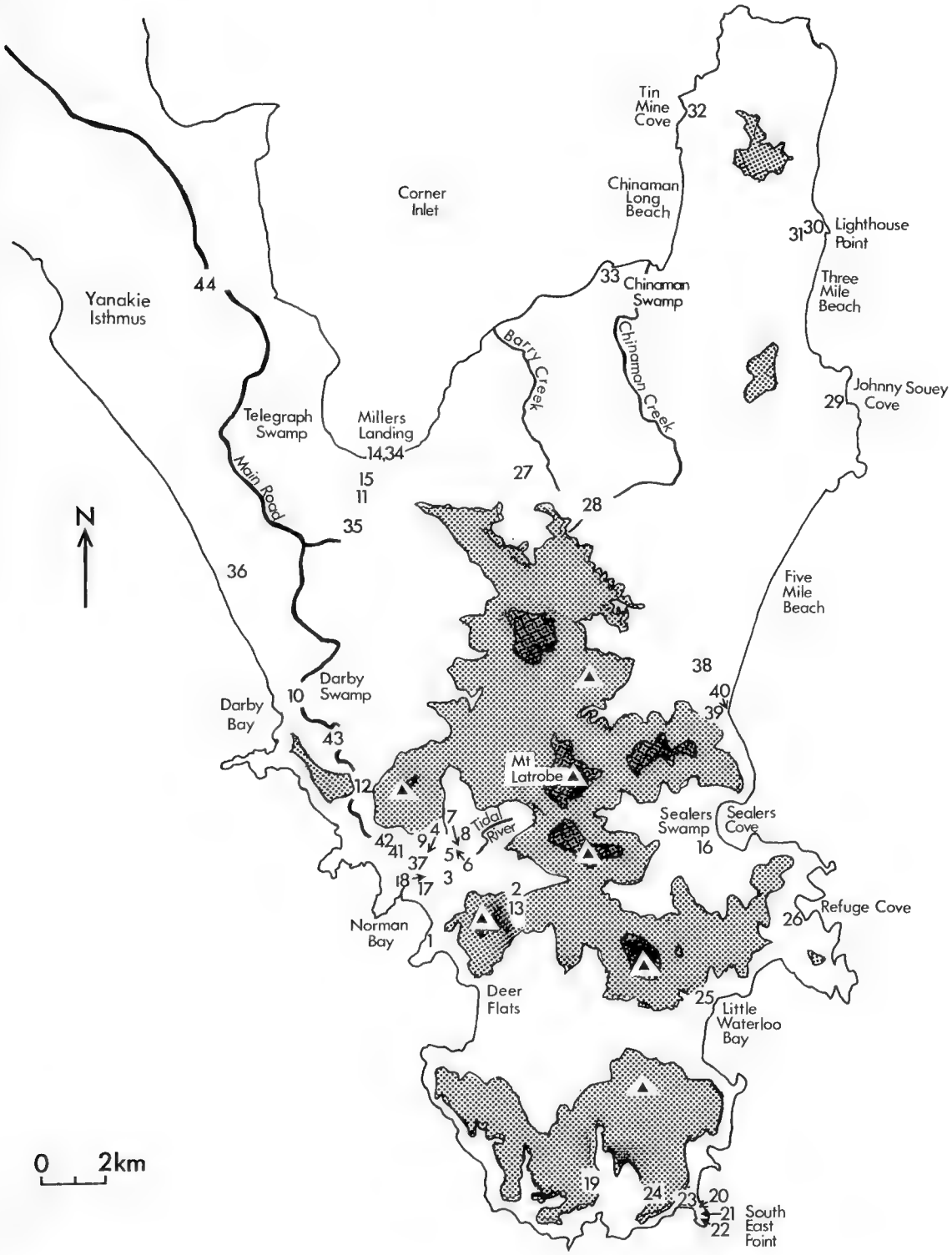
The vascular flora is well known, and a species list has been published by the National Parks Service (Anon., 1972a). Lower plants are less well known, but some information can be obtained from Garnet (1971), Ashton and Frankensberg (1976) and Ashton and Webb

Table 2. List of collecting sites at Wilsons Promontory with grid reference, vegetation type, locality and date. Sites are shown in Map B by the site numbers allocated in this table.

Site No.	Grid reference	Vegetation type	Locality	Date
1	414778	*Casuarina stricta*	Little Oberon Bay	
2	442792	Low eucalypt woodland	Telegraph Saddle	
3	422798	*Melaleuca ericifolia* scrub	Waterpump shed	
4	416804	Closed heath	Lilly Pilly track	
5	423804	Closed scrub	" " "	
6	425805	*Pteridium esculentum*	" " "	
7	426807	Tall open forest	" " "	
8	427810	Closed forest	" " "	
9	415806	Low open forest	" " "	
10	372857	Coastal dune vegetation	Darby Beach track	
11	395920	*Banksia serrata*	Millers Landing track	
12	393826	Closed heath	Darby Ridge	12 Apr 1982
13	442789	*Banksia* sp.	S of Telegraph Saddle	3 Apr 1983
14	400933	*Melaleuca ericifolia* scrub	Millers Landing, shore	
15	397926	Open heath	Millers Landing track	
16	502805	Closed forest	Sealers Cove track	23 Apr 1984
17	414793	*Leptospermum laevigatum*	Botany lab., Tidal River	
18	414796	*Banksia integrifolia*	Tidal River	30 Nov 1990
19	469699	Tall open forest	Roaring Meg Camping area	25 Apr 1989
20	502688	Closed heath	South East Point	26 Apr 1989
21	502687	*Casuarina stricta*	South East Point	26 Apr 1989
22	502686	Coastal vegetation	South East Point	26 Apr 1989
23	499689	*Banksia* scrub	Lighthouse lookout	26 Apr 1989
24	487694	Closed heath	Lighthouse track	26 Apr 1989
25	505756	*Acmena smithii*	Little Waterloo Bay	27 Apr 1989
26	536782	*Leptospermum laevigatum*	Refuge Cove	27 Apr 1989
27	448926	Open heath	Barry Creek	13 Apr 1990
28	468918	Closed forest	Chinaman Creek	
29	549949	Coastal vegetation	Johnny Souey Cove	14 Apr 1990
30	540005	*Banksia* woodland	Mt Margaret track	15 Apr 1990
31	536004	*Melaleuca squarrosa* scrub	Mt Margaret track	15 Apr 1990
32	498042	Coastal vegetation	Tin Mine Cove	16 Apr 1990
33	473995	*Avicennia marina*	W of Chinaman Swamp	16 Apr 1990
34	402933	*Avicennia marina*	Millers Landing	17 Apr 1990
35	391910	Open scrub carpark	S of Millers Landing	17 Apr 1990
36	355897	*Leptospermum lanigerum*	Cotters Lake	18 Apr 1990
37	412802	Closed heath	Pillar Pt track	10 Apr 1982
38	503862	Closed forest	inland of Freshwater Lake	5 Apr 1991
39	510851	*Acmena smithii*	southern end, Five Mile Beach	6 Apr 1991
40	511851	Coastal vegetation	southern end, Five Mile Beach	6 Apr 1991
41	405804	Open heath	Turnoff to Squeaky Beach	7 Apr 1991
42	403808	Closed scrub	Beside main road	7 Apr 1991
43	386841	*Banksia serrata*	Beside main road	7 Apr 1991
44	346985	Coastal vegetation	Stockyard Camp	7 Apr 1991



Map A. Bass Strait, showing position of Wilsons Promontory in relation to the bathymetry and the Bass Strait islands. Submarine contours in fathoms.



Map B. Wilsons Promontory, showing collecting sites as numbered in Table 2. Contours are 200 m and 500 m.

(1977). The number of species of native and introduced vascular plants found in the park (up to July 1978) is shown in Table 1.

The structure of the vegetation is quite diverse. In general, forests are associated with the mountains of Palaeozoic granite. On the surrounding Quarternary sands trees are usually much shorter and more widely spaced or even absent, the plant communities in these areas being dominated by shrubs and herbs.

Sampling localities and methods

Originally eleven of the vegetation units (habitats) described by Smith (1978) were chosen for sampling on grounds of accessibility, the need to sample the widest possible range of habitats in the time available, and for comparison with habitats of a similar survey carried out by Smithers (1977) at Muogamarra Nature Reserve. These habitats (sites 1–11, Table 2, Map B) were systematically sampled over 13 months (22 Jan 1985–23 Feb 1986) on 18 occasions. On each occasion in each habitat ten samples were taken, each sample obtained by beating a branch of a tree or shrub 12 times. Where a number of plant species were present in a habitat, care was taken to ensure that all were sampled. From each of the remaining habitats (Table 2) 20 of these samples were taken once on the date shown, except those of sites 15, 17 and 28, which were sampled twice, and site 14 which was sampled on three occasions. Dislodged insects were aspirated from the beating tray (0.7 m^2) and preserved in 75% alcohol. Smith (1978) provides floristic information on all habitats sampled; the six-digit grid reference (Table 2) refers to the 1:50 000 Vicmap series of Wilsons Promontory. Sorting and specimen preparation involved standard techniques (New, 1977).

Checklist of Psocoptera from Wilsons Promontory National Park, Victoria

Lepidopsocidae

Echmepteryx (Loxopholia) albigena sp. nov.
E. (L.) renoides sp. nov.

Trogiidae

Cerobasis guestfalica (Kolbe, 1880)
Lepinotus reticulatus Enderlein, 1905

Caeciliidae

Caecilius concavistigma sp. nov.
C. ericifoliae sp. nov.
C. juneae sp. nov.
C. pteridii Smithers, 1977
C. quercus Edwards, 1950
C. semifuscatus (Tillyard, 1923)
C. wilsoni sp. nov.
Enderleinella hilli Smithers, 1979
E. selta sp. nov.

Amphipsocidae

Taeniostigma trickettae Smithers, 1974

Ectopsocidae

Ectopsocus acutistigma sp. nov.
E. australis sp. nov.
E. axillaris (Smithers, 1969)
E. briggsi McLachlan, 1899
E. californicus (Banks, 1903)
E. edwardsi New, 1973
E. pteridii Smithers, 1977
E. rileyae sp. nov.

Peripsocidae

Peripsocus bifasciatus sp. nov.
P. maoricus (Tillyard, 1923)
P. melaleucae New, 1971
P. milleri (Tillyard, 1923)
P. tillyardi New, 1973

Table 1. Number of native and introduced species of vascular plants recorded from Wilsons Promontory National Park by 1978 (Smith, 1978)

Group	Native	Introduced	Total
Ferns and fern allies	60	-	60
Flowering plants			
Monocotyledons	248	35	283
Dicotyledons	433	82	515
Total	741	117	858

Pseudocaeciliidae

Austropsocus antennalis Thornton and New, 1977
A. cornutus sp. nov.
A. costalis Thornton and New, 1977
A. hyalinus Thornton, Wong and Smithers, 1977
A. sinuosus (Banks, 1939)
A. tibialis Thornton and New, 1977
A. viridis (Enderlein, 1903)
Cladioneura pulchripennis Enderlein, 1906
Heterocaecilius brunellus (Tillyard, 1923)
H. lachlani (Enderlein, 1903)
Pseudoscottiella papillosa sp. nov.
P. rotundata New, 1974
P. tanei Smithers, 1977
P. yenoides sp. nov.

Philotarsidae

Aaroniella rawlingsi Smithers, 1969
Haplophallus sinus Thornton and New, 1977
Latrobiella fenestrata sp. nov.
L. guttata (Tillyard, 1923)

Elipsocidae

Drymopsocus brunneus Smithers, 1963
Pentacladus eucalypti Enderlein, 1906
Propsocus pulchripennis (Perkins, 1899)
Spilopsocus masseyi New, 1971
S. serratus sp. nov.

Psocidae

Blaste bistriata sp. nov.
B. forficula sp. nov.
B. lignicola (Enderlein, 1906)
B. taylori New, 1974
B. tillyardi Smithers, 1969
Clematostigma lunulata sp. nov.
C. maculiceps (Enderlein, 1903)
C. striata sp. nov.
Ptycta australis sp. nov.
P. campbelli sp. nov.
P. glossoptera New, 1974
P. muogamarra Smithers, 1977
P. prosta sp. nov.
P. umbrata New, 1974
Sigmatoneura formosa (Banks, 1918)
Tanystigma inglewoodense (New, 1974)
T. valvula sp. nov.

Myopsocidae

Myopsocus australis (Brauer, 1865)

Systematics

In the following systematic treatment drawings from permanent preparations were made with the aid of a camera lucida by Ms J. Browning. Measurements of body parts are given in mm, and the method used for determining the ratio of interocular distance to diameter of eye (IO:D in systematic treatment below) was that of Pearman, as described by Ball (1943). The following abbreviations are used: B, body length; ct, number of ctenidia on hind tarsal segments; F, length of hind femur; f_1, length of basal flagellar segment; f_2, length of second flagellar segment; FW, length of fore wing; HW, length of hind wing; T, length of hind tibia; t_1, t_2, t_3, length of basal, second and apical tarsal segments respectively; rt, ration of t_1 and t_3 to t_2. Localities are enumerated in Table 2. Holotypes, allotypes and paratypes are deposited in the Australian Museum, Sydney. Remaining material is either deposited in the Museum of Victoria or retained in the authors' collections.

Lepidopsocidae Pearman

Echmepteryx Aaron

Echmepteryx Aaron, 1886: 17. Type species: *Imphientomum hageni* Packard.

Echmepteryx (Loxopholia) Enderlein

Loxopholia Enderlein, 1931: 225. Type species: *Loxopholia pinnula* Enderlein = *Echmepteryx (Loxopholia) pinnula*. — Roesler, 1944: 133.

Remarks. Since only six species of *Echmepteryx (Loxopholia)* Enderlein are known from Australia we provide a key to the Australian species.

Key to Australian species of *Echmepteryx (Loxopholia)* Enderlein

1. Ocelli present 2
— Ocelli absent ..... *E. howensis* Smithers and Thornton
2. Fore wing apically spear-shaped (in hind wing vein r_1 arising distal to vein m_1) 3
— Fore wing shape normal (in hind wing vein m_1 opposite or arising distal to vein r_1) 5

3. Fore wing with brown membrane and a hyaline fascia in apical third 4
— Fore wing barely tinged pale brown, no fascia *E. hartmeyeri* Enderlein
4. Gena pale cream posteriorly, large basal brown cloud in fore wing having small hyaline areas ..... *E. albigena* sp. nov.
— Gena dark brown, large basal brown cloud in fore wing lacking hyaline areas ..... *E. quadrilineata* Smithers
5. Epicranial suture distinct, dark brown; coxa, femur of legs dark brown; fore wing membrane brown except for colourless apex, venation distinct ..... *E. brunnea* Smithers
— Epicranial suture not distinct; coxa, femur of legs pale cream; fore wing membrane with brown and hyaline areas, venation not distinct ..... *E. renoides* sp. nov.

Echmepteryx (Loxopholia) albigena sp. nov.

Figures 1–9

Material examined. Holotype ♂ : Refuge Cove, *Leptospermum laevigatum*, 27 Apr 1989. Allotype ♀, 2♂ and 1♀ paratypes: same data as holotype (K73372–K73376). Additional records (2♀, 1 nymph): site 19, site 28 (Apr 1990).

Description of male. Coloration (after ca 1 yr in alcohol). Head cream with brown markings as in fig. 1. Maxillary palps pale cream, distal half of apical segment grey-brown. Genae posteriorly pale cream. Scape and pedicel grey-brown, antennae brown. Fore wing (fig. 2) membrane brown with paler markings, veins in various shades of brown. Hind wing (fig. 3) hyaline, veins brown. Prothorax pale. Mesothoracic nota pale brown, pale buff anterolaterally. Metathorax pale buff, brown medially. Thoracic pleura cream with longitudinal grey-brown narrow line. Legs with coxa, trochanter and femur cream, femur brown apically; tibia brown with narrow buff band basally, broader buff bands apically and at mid-length; basal tarsal segment brown over basal third, otherwise creamy buff, second segment pale brown, apical segment pale buff. Abdomen cream, with brown terminal structures.

Morphology. IO:D = 2.2. Antennae complete, with 38 flagellar segments. Stout brown setae on brown stripes on vertex, on lateral areas of frons and on anterior edges of genae. 3 ocelli, anterior ocellus slightly smaller than lateral ocelli. Fore wing with asymmetrical scales on membrane, marginal scales narrow. Both fore and hind wings (figs 2, 3) spear-shaped apically, similar to *Echmepteryx (Loxopholia) quadrilineata* Smithers. In hind wing vein r_{2+3} 3 times, r_{4+5} 5.3 times, length of stalk of radial fork. Rasp of Pearman's organ well developed. Basal hind tarsal segment with 15 ctenidia. Claw with stout subapical tooth, pulvillus narrow. Epiproct (fig. 4) simple, setose. Paraproct (fig. 4) with field of 6 trichobothria and 1 seta without a basal rosette; posterior spine blunt. Hypandrium (fig. 5) semicircular, setose. Phallosome (fig. 6).

Dimensions. B 2.5, FW 2.54, HW 1.92, F 0.88, T 1.15, t_1 0.480, t_2 0.080, t_3 0.080, rt 6.0:1:1.0, f_1 0.059, f_2 0.055, f_1/f_2 1.07.

Description of female. Coloration (after ca 1 yr in alcohol). As male.

Morphology. IO:D = 2.2. General morphology similar to that of male. Epicranial and frons-vertex sutures more clearly discernible than in male. In hind wing vein r_{2+3} 2.7–5.5 times, vein r_{4+5} 5–9 times, length of stalk of radial fork. Epiproct (fig. 7). Paraproct (fig. 7) with 7 (and 6) setae in basal rosettes and 1 seta without a rosette; field of setae on mesial surface with 2 setae at least twice as long as remaining 18; posterior spine blunt. Subgenital plate (fig. 8). Gonapophyses (fig. 9).

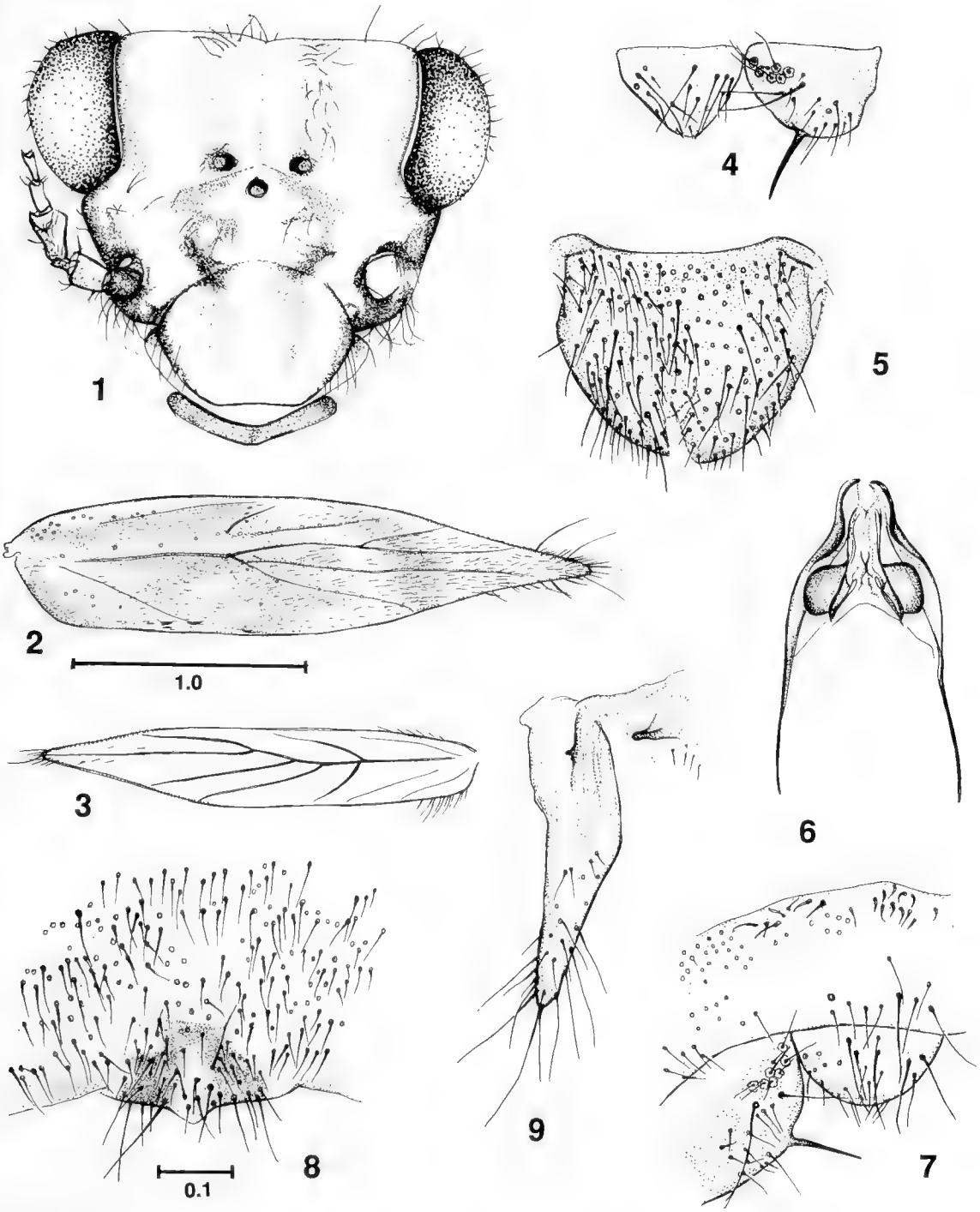
Dimensions. B 2.8, FW 2.48, HW 1.95, F 0.92, T 1.15, t_1 0.513, t_2 0.166, t_3 0.158, rt 3.1:1:1.1, f_1 0.059, f_2 0.047, f_1/f_2 1.25.

Remarks. This species resembles *Echmepteryx quadrilineata* in details of pattern of brown pigment on the fore wing membrane and in head pattern. *E. quadrilineata*, however, lacks the small hyaline areas within the large basal brown cloud in the fore wing, and has dark brown genae. The head pattern is very similar to the typical form of *Lepidopsocus fasciatus* Thornton, which, however, is clearly a member of the genus *Lepidopsocus* Enderlein on wing venation.

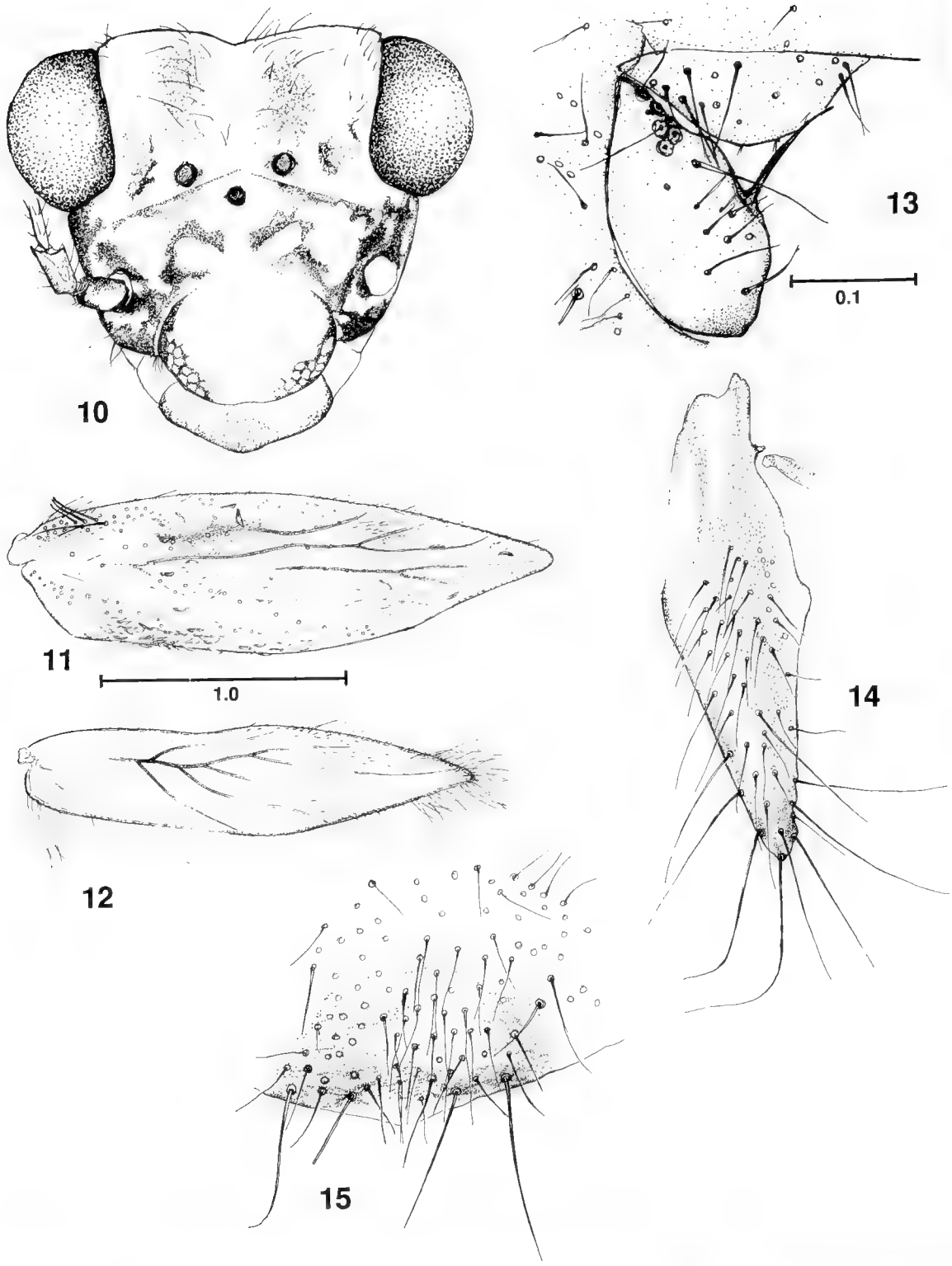
Echmepteryx (Loxopholia) renoides sp. nov.

Figures 10–17

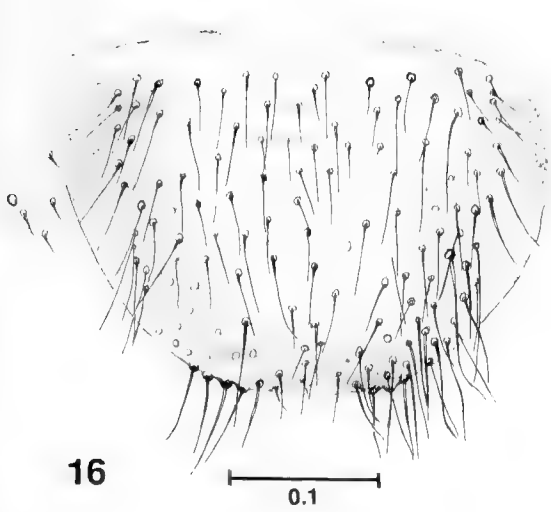
Material examined. Holotype ♀: Darby Beach Track, coastal dune vegetation, 23–26 Jun 1985. Allotype ♂, 2 nymphs, 3♀ and 1♂ paratypes: same data as holotype (K73377–K73382). Additional records (46♀, 7♂, 56 nymphs): site 1 (May 1985, Jan 1986), site 10

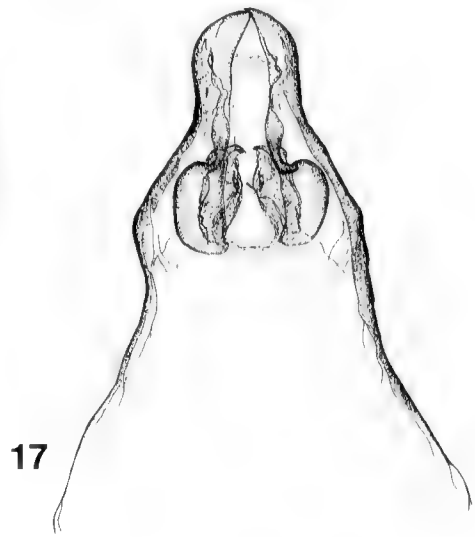


Figures 1–9. *Echmepteryx albigena*. Male: 1, head; 2, forewing; 3, hindwing; 4, epiproct and paraproct; 5, hypandrium; 6, phallosome. Female: 7, epiproct and paraproct; 8, subgenital plate; 9, gonapophyses. Figure 1 not to scale. Figures 2, 3 and 4–9 to common scales.



Figures 10–15. *Echmepteryx renoides*. Female: 10, head; 11, forewing; 12, hindwing; 13, epiproct and paraproct; 14, gonapophyses; 15, subgenital plate. Figure 10 not to scale. Figures 11, 12 and 13–15 to common scales.





Figures 16–17. *Echmepteryx renoides*. Male: 16, hypandrium; 17, phallosome. Figures 16 and 17 to common scale.

(Apr, May, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 12, site 14 (Apr 1984, Apr 1990 – nymph only, Jan 1991), site 17 (Jan 1985, Dec 1990), site 44.

Description of female. Coloration. (after ca 5 yr in alcohol). Head pale buff with distinct markings (fig. 10); brown mark from orbit fuses with brown area surrounding base of antenna; gena with dark band below antennal socket parallel to antennal-orbital band; labrum dark grey in distal half, white in basal half, a dark grey median band from distal grey area to base of labrum. Antennae light brown, eyes black. Maxillary palps very pale buff, apical and subapical segments pale grey-brown. Mesonotum brown, thoracic pleura with brown band running above coxae. Legs: coxa, trochanter and femur pale cream, femur with apical brown patch on lateral face and a smaller subapical black patch on both faces, continuing over ventral surface; tibia buff with broad basal and subapical bands; basal tarsal segment brown basally fading to buff quarter along length, other segments buff. Fore wing membrane (fig. 11) with brown and hyaline areas, macrosetae on veins brown; hind wing (fig. 12) hyaline, veins brown. Abdomen pale whitish-cream, tergites with grey marks along anterior edges laterally, sterna grey-brown laterally, abdomen from beneath thus appearing to have the broad lateral bands enclosing a whitish-cream area.

Morphology. IO:D = 2.5. Head with long strong setae, grouped particularly on pigmented areas and posterior to brown vertex marks. Flagellum with 38 segments. Setae on fore wing veins 4 times length and ca 10 times thickness of membrane setae, scales asymmetrical; macrosetae on veins and apical marginal setae with short sharp spinelets on one side over apical quarter. Epiproct (fig. 13) triangular, setose; paraproct (fig. 13) with trichobothrial field of 6 setae in rosette sockets and 1 without such a socket; mesial spine long, slightly curved, sharp. Gonapophyses (fig. 14). Subgenital plate (fig. 15).

Dimensions. B 2.4, FW 2.15, HW 1.62, F 0.67, T 1.06, t_1 0.434, t_2 0.103, t_3 0.079, rt 4.2:1:1.3, f_1 0.055, f_2 0.036, f_1/f_2 1.55.

Description of male. Coloration (after ca 5 yr in alcohol). As female.

Morphology. IO:D = 2.5. General morphology similar to that of female. Epiproct semicircular, setose; paraprocts as for female. Hypandrium (fig. 16). Phallosome (fig. 17), parameres divergent, meeting apically, a prominent pair of kidney-shaped sclerites within parameres.

Dimensions. B 2.1, FW 2.27, HW damaged, F 0.71, T 1.00, t_1 0.419, t_2 0.103, t_3 0.079, rt 4.1:1:1.3, f_1 0.047, f_2 0.039, f_1/f_2 1.20.

Description of nymph. Coloration (after ca 5 yr in alcohol). Head pattern as adult, slightly simplified, thorax dorsally with 2 longitudinal grey-

brown bands extending to first abdominal tergite where they widen slightly.

Remarks. This species generally resembles *Echmepteryx (Thylacopsis) picta* Smithers from New South Wales. It was found predominantly on coastal dune vegetation (site 10) and also occurred on *Casuarina* (site 1), *Melaleuca* (site 14) and *Leptospermum* (site 17). The two species can easily be separated on details of hind wing venation.

Trogiidae Enderlein

Cerobasis Kolbe

Cerobasis Kolbe, 1882: 212. Type species: *Cerobasis muraria* Kolbe.

Cerobasis guestfalicus (Kolbe)

Hyperetes guestfalicus Kolbe, 1880: 132.
Cerobasis guestfalicus. — Roesler, 1943: 13.

Material examined. 328♀, 46 nymphs: site 1 (Feb, Mar, May, June, July, Aug, Sep, Oct, Nov, Dec 1985, Jan 86), site 3 (Feb, Apr 1985), site 4 (Feb, May, Jul 1985, Jan 1986), site 10 (Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 11 (Feb, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 12, site 17 (Dec 1990), site 20 – nymph only, site 26, site 29, site 36, site 41.

Remarks. This cosmopolitan species has been recorded previously from South Australia, Victoria and Curtis Island. It was collected at Wilsons Promontory predominantly from coastal dune vegetation (site 10) and coastal *Casuarina stricta* (site 1), as well as from *Banksia serrata* (site 11).

Lepinotus Heyden

Lepinotus Heyden, 1850: 84. Type species: *Lepinotus inquilinus* Heyden.

Lepinotus reticulatus Enderlein

Lepinotus reticulatus Enderlein, 1905: 31.

Material examined. 15♀: site 6 (May 1985), site 10 (May, Nov 1985, Feb 1986), site 11 (Apr, May, Jun 1985), site 26, site 32, site 40.
Remarks. Collected on bracken (site 6), *Banksia serrata* (site 11), and coastal dune and heath vegetation, this cosmopolitan domestic species has been recorded from Curtis Island and South Australia.

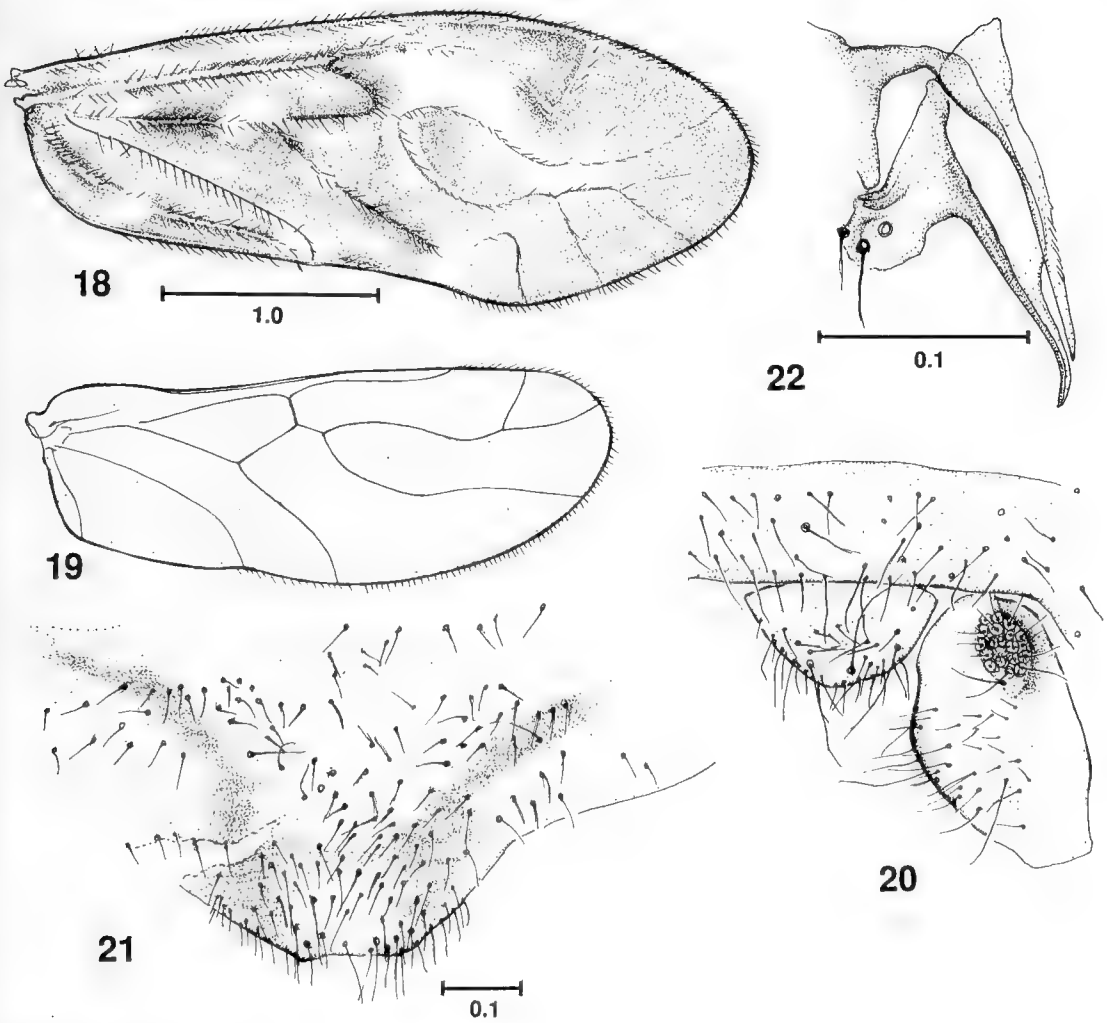
Caeciliidae Pearman

Caecilius Curtis

Caecilius Curtis, 1837: 648. Type species: *Psocus fuscopterus* Latreille.

Key to species of *Caecilius* from Wilsons Promontory

1. Fore wing pale, yellowish, uniform, sometimes cell 1A darker than rest of membrane 2
— Fore wing with blotched or clear-cut pattern 4
2. Fore wing with vein cu_2 glabrous, cell 1A darker than rest of membrane 3
— Fore wing with vein cu_2 setose, cell 1A not darker than rest of membrane ..... *C. ericifoliae* sp. nov.
3. A dark mark between eye and epistomial suture . *C. pteridii* Smithers
— No dark mark between eye and epistomial suture *C. quercus* Edwards
4. Postclypeus with distinct striae, maxillary palp dark brown 5
— Postclypeus uniform brown, lacking distinct striae, maxillary palp pale brown 6
5. Fore wing with 3 hyaline areas in angles at bifurcation of vein $m + cu$ ..... *C. semifuscatus* (Tillyard)
— Fore wing lacking hyaline areas in angles at bifurcation of vein $m + cu$ ..... *C. wilsoni* sp. nov.
6. Head pattern with dark X-mark centred on ocellar protuberance, fore wing with pterostigmal spur vein ..... *C. juneae* sp. nov.
— Head pattern lacking dark X-mark centred on ocellar protuberance, fore wing lacking pterostigmal spurvein ..... *C. concavistigma* sp. nov.



Figures 18–22. *Caecilius concavistigma*. Female: 18,forewing; 19,hindwing; 20,epiproct and paraproct; 21,subgenital plate; 22, gonapophyses. Figures 18, 19 and 20–22 to common scales.

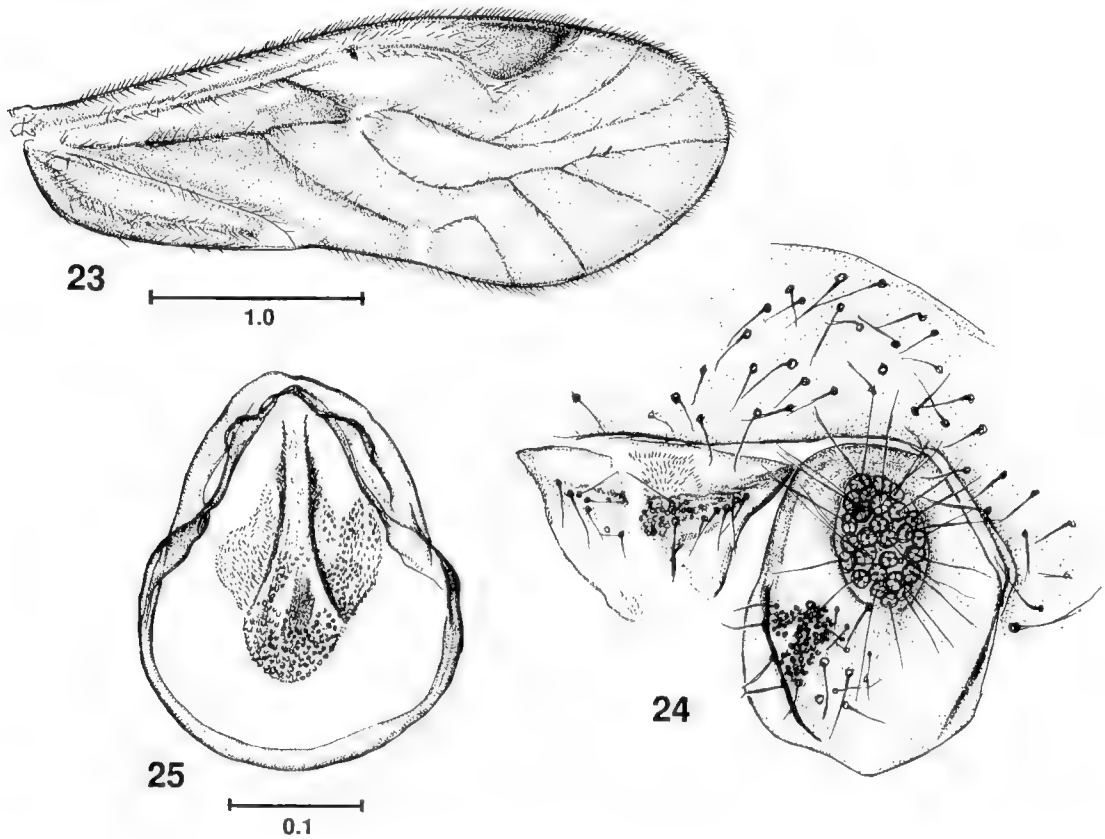
Caecilius concavistigma sp. nov.

Figures 18–25

Material examined. Holotype ♀: Lilly Pilly Nature Track, tall open forest, 20–21 Nov 1985; allotype ♂: same data as holotype; 2 nymphs, 2♀ and 1♂ paratypes: Little Waterloo Bay, *Acmena smithii*, 27 Apr 1989 (K73383–K733987). Additional records (2♀, 1♂, 2 nymphs): site 7 (Feb 1986 – nymph only), site 14 (Jan 1991), site 18, site 19.

Description of female. Coloration (after ca 6 yr in alcohol). Head buff with following very pale brown: markings dorsal and behind orbit; indistinct striae on postclypeus; scape, pedicel and first three flagellar segments. Remaining flagellar segments, tip of apical segment of maxillary palp and labrum brown. Eyes black. Ocelli pale, inner margins dark brown. Dorsa and sides of thorax brown, sutural areas paler. Legs buff, except dorsal half of coxa and apical tarsal segment brown; claws black. Fore wing (fig. 18) with hyaline and pigmented areas. Hind wing (fig. 19) faintly tinged brown. Abdominal segments dorsally mauve (faded in holotype), paler ventrally.

Morphology. IO:D = 5.0. Clypeal shelf intermediate. Labral stylets small, spiculate; labral sensillae 5 in all; internal labral sclerotization present.



Figures 23–25. *Caecilius concavistigma*. Male: 23, forewing; 24, epiproct and paraproct; 25, phallosome. Figures 24 and 25 to common scale.

Lacinia broad, flat, expanded preapically on 1 side, with apical denticles. Fore wing with basal section of pterostigma strongly concave, vertex sharply angled; areola postica trianguloid; vein cu_2 strongly setose; veins *m + cu, r, an* and the basal section of cu_1 with setae in 2 ranks, setae of remaining veins in single rank. Mesothoracic precoxal suture absent. Epiproct (fig. 20) bearing 3 large preapical setae, semicircular, setose. Paraproct (fig. 20) with oval field of 21 trichobothria, 1 seta not in rosette; inner margin sclerotised. Subgenital plate (fig. 21) apically lightly sclerotised, with V-shaped sclerotisation basally; lateral apical margins with small, very shallow apophyses; setose. Gonapophyses (fig. 22).

Dimensions. B 3.2, FW 3.36, HW 2.60, F 0.71, T 1.12, t_1 0.326, t_2 0.134, rt 2.4:1, ct 0, 0, f_1 0.614, f_2 0.384.

Description of male. Coloration (after ca 6 yr in alcohol). As female, with following exceptions: head and antenna brown; epicranial suture dark brown; tibia and basal tarsal segment pale brown; fore wing (fig. 23) more uniformly pigmented brown than that of female, hyaline patches reduced; abdomen cream, terminal segments brown.

Morphology. IO:D = 1.65. Clypeus, labrum and lacinia as in female. Ocelli on slightly raised tubercle. Epicranial suture not reaching ocelli. Basal flagellar segment not enlarged, slightly bent. Basal section of pterostigma less concave than that of female, angle of vertex less acute. Setae on fore wing veins distributed as in female. Mesothoracic precoxal suture as in female. Tibiae of uniform width, swellings absent. Epiproct (fig. 24, damaged) bearing 2 large preapical setae in surrounding rugose field, line of setae each side of field; broad, shallow. Paraproct (fig. 24) with oval field of 28 trichobothria, 2 setae not in rosettes; near sclerotised inner margin a rugose field with associated setae. Hypandrium

simple, setose; longer setae on posterolateral margins. Phallosome (fig. 25).

Dimensions. B 2.4, FW 3.27, HW 2.51, F 0.68, T 1.15, t_1 0.348, t_2 0.142, rt 2.4:1, ct 23, 0, f_1 0.624, f_2 0.432.

Remarks. This is a species of tall open forest. In fore wing pattern *C. concavistigma* is similar to *Caecilius juneae* (below) and *Caecilius macrostigma* Enderlein. Vein cu_2 of the fore wing is heavily setose in these species (described as the *analis* vein for *C. macrostigma* by Enderlein, 1903: 272 and fig. 4). *C. concavistigma* may be distinguished from *C. macrostigma* by the latter's very broad pterostigma, and it differs from *C. juneae* in details of head pattern and in lacking a pterostigmal spur vein on the fore wing.

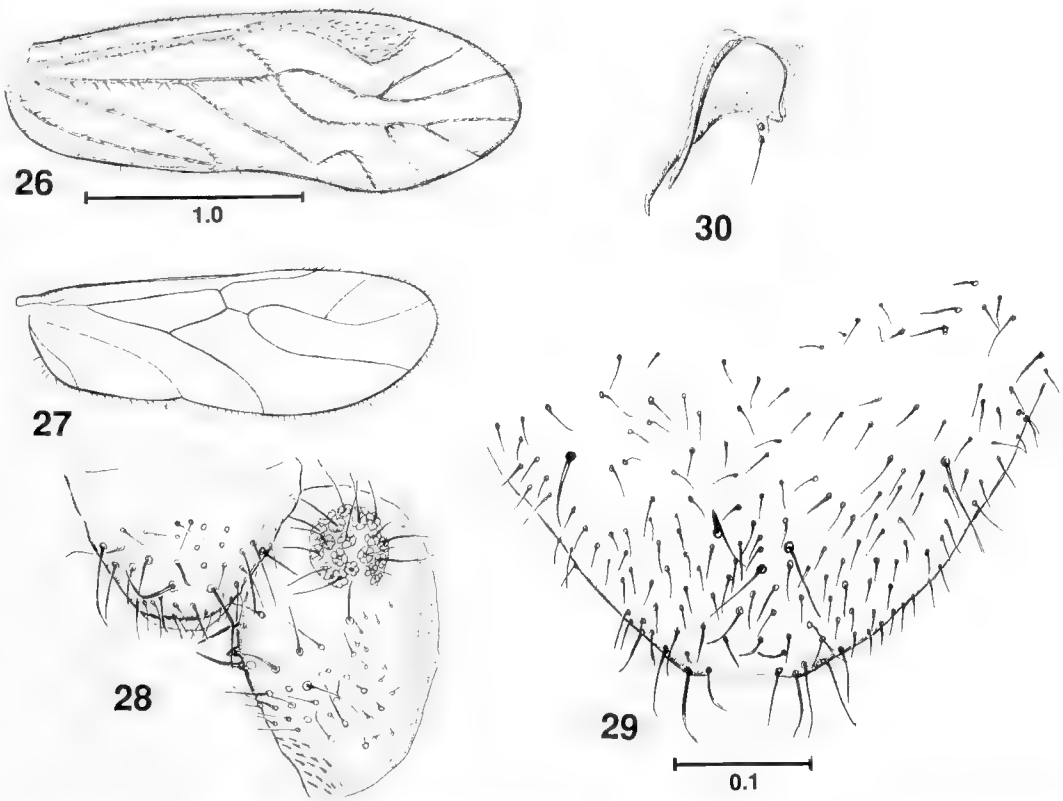
Caecilius ericifoliae sp. nov.

Figures 26–35

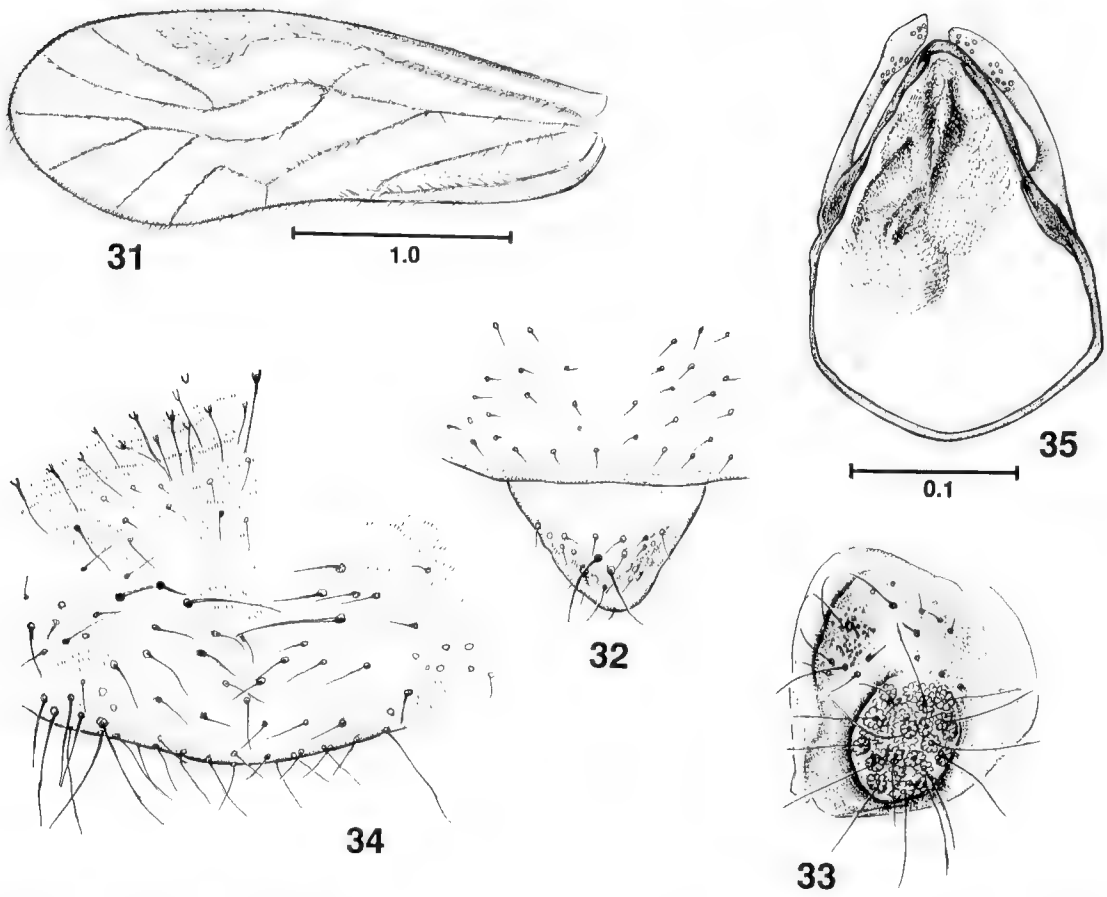
Material examined. Holotype ♀: Waterpump shed, *Melaleuca ericifolia* scrub, 5–6 Jan 1986; allotype ♂, same locality as holotype, 21–23 Apr 1985; 5 nymphs, 31♀ and 20♂ paratypes: same data as holotype (K73388–K73440). Additional records (89♀, 76♂, 15 nymphs): site 3 (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 14 (Apr 1984, Apr 1990), site 21, site 23.

Description of female. Coloration (after ca 5 yr in alcohol). Whole insect pale yellowish-buff with following exceptions: eyes and inner border of ocelli black; faint brown patches of pigment mesad of orbit and each side of epicranial suture; distal end of apical segment of maxillary palp brown; scape, pedicel and flagellar segments 3 to 11 brown; claw and distal two-thirds of apical tarsal segment brown.

Morphology. IO:D = 10, eyes small. Clypeal shelf intermediate. Labral stylets small, spiculate; labral sensillae 5 in all; internal labral sclerotization absent. Lacinia broad, flat, expanded preapically on 1 side, with apical denticles. Pterostigma of fore wing (fig. 26) with prominent posterior angle, vein cu_2 setose. Mesothoracic precoxal suture absent. Hind wing (fig.



Figures 26–30. *Caecilius ericifoliae*. Female: 26, forewing; 27, hindwing; 28, epiproct and paraproct; 29, subgenital plate; 30, gonapophyses. Figures 26, 27 and 28–30 to common scales.



Figures 31–35. *Caecilius ericifoliae*. Male: 31, forewing; 32, epiproct; 33, paraproct; 34, hypandrium; 35, phallosome. Figures 32–35 to common scale.

27). Epiproct (fig. 28) trapezoid, setose, a pair of prominent setae some distance from posterior margin. Paraproct (fig. 28) with a circular field of 19 trichobothria and 1 seta not in a rosette. Subgenital plate (fig. 29) setose, with short straight posterior margin, slightly sclerotised at posterior angles. Gonapophyses (fig. 30).

Dimensions. B 2.0, FW 2.33, HW 1.89, F 0.52, T 0.81, t_1 0.240, t_2 0.135, rt 1.8:1, ct 19, 0, f_1 0.387, f_2 0.288.

Description of male. Coloration (after ca 5 yr in alcohol). As female.

Morphology. IO:D = 5.5. Clypeus, labrum and lacinia as in female. Basal flagellar segment not enlarged or bent. Fore wing (fig. 31) as female but larger. Mesothoracic precoxal suture as in female. Tibiae of uniform width, swellings absent. Epiproct (fig. 32) trianguloid, pair of very long setae some distance from posterior margin. Paraproct (fig. 33) with field of 20 trichobothria and 1 seta not in rosette; spiculate field posteriorly near mesial margin. Hypandrium (fig. 34) simple, posterior margin slightly sinuous and somewhat sclerotised. Phallosome (fig. 35) with large lobed spiculate penial bulb.

Dimensions. B 1.7, FW 2.71, HW 2.18, F 0.52, T = 0.87, t_1 0.260, t_2 0.125, rt 2.1:1, ct 19, 0, f_1 0.474, f_2 0.347.

Remarks. This species was taken predominantly on *Melaleuca ericifolia* (sites 3, 14). It is similar to *Caecilius flavistigma* Tillyard from New Zealand, which also has vein cu_2 of the fore wing setose. In *C. flavistigma*, however, the anal cell of the fore wing is fuscous.

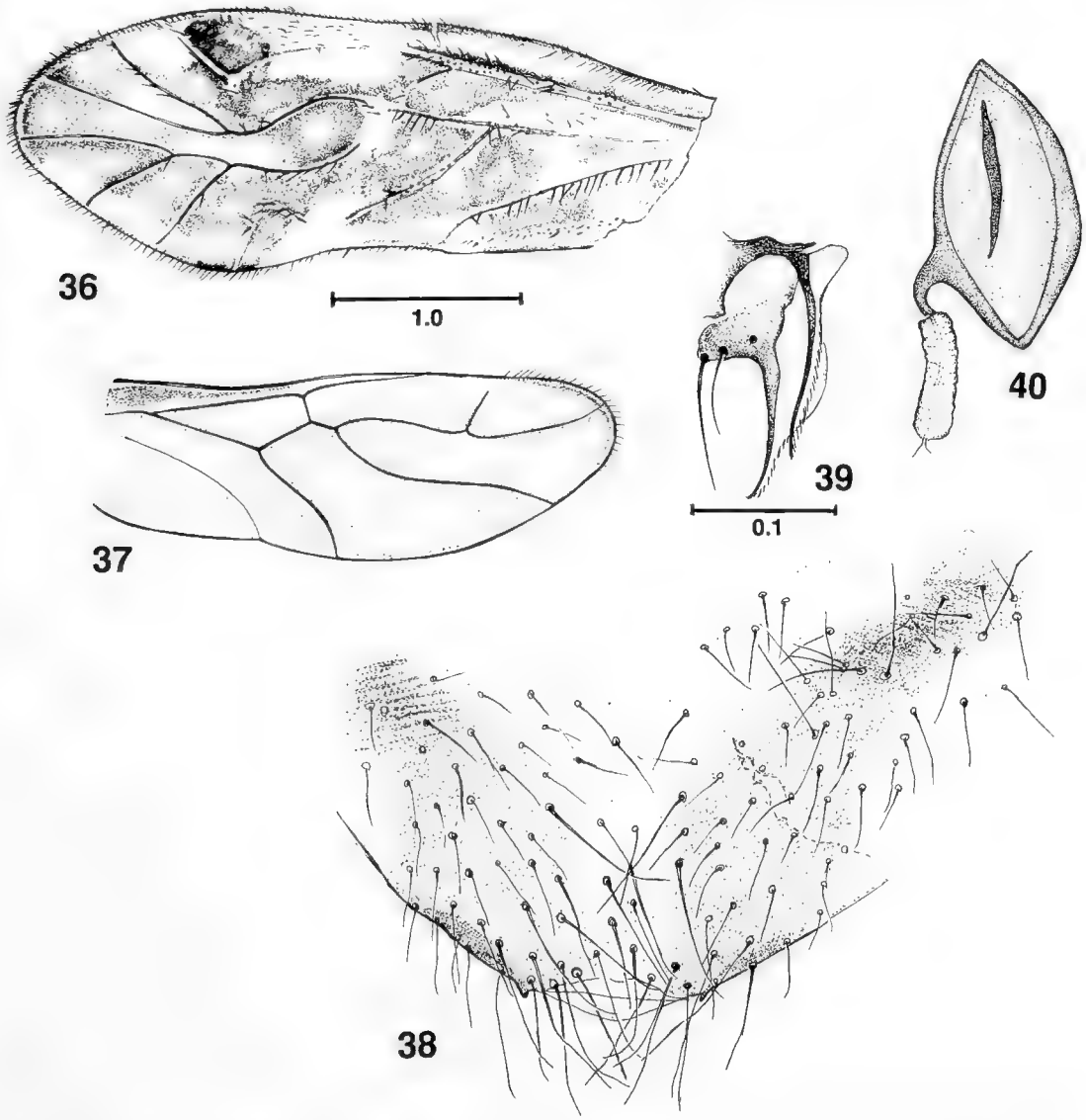
Caecilius juneae sp. nov.

Figures 36–43

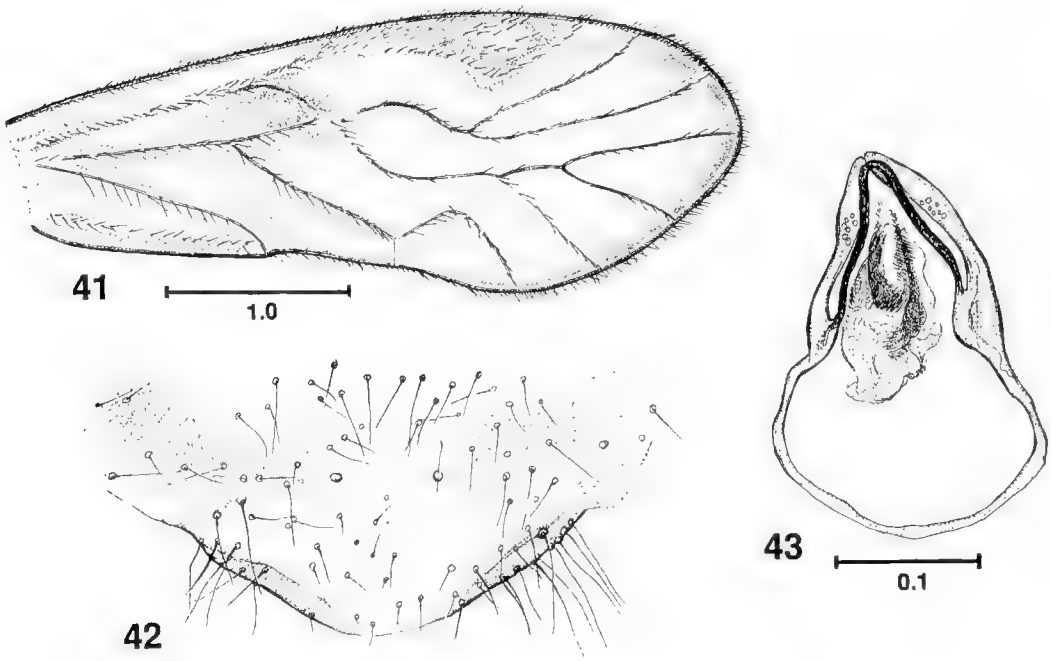
Material examined. Holotype ♀: 'The Loop', Lilly Pilly Nature Track, closed forest, 12–15 Mar 1985. Allotype

♂, 1♀ and 1♂ paratypes: same locality as holotype, 29 Sep–1 Oct 1985 (K73441–K73444). Additional records (10♀, 11♂, 10 nymphs): site 7 (Nov 1985 – nymph only, Jan, Feb 1986), site 8 (Nov, Dec 1985, Jan 1986, Jan 1991) site 19, site 25, site 28 (Apr 1990), site 42.

Description of female. Coloration (after ca 5 yr in alcohol). Head: ground color buff with the following brown: a band along posterior margin of vertex each side of but not reaching epicranial suture; a brown cloud each side of epicranial suture in middle of vertex; fused pigment patches mesad of orbits; stirrup mark in middle of frons; postclypeus; labrum. The following markings are dark grey-black: ocellar protuberance, each side of this and more posteriorly a cloud larger than protuberance and connected to it by a narrow band; a band from protuberance to antennal socket along anterior margin of vertex, from socket to orbit, and posterior of orbit over posterior angle of vertex. Eyes black. Apical segment of maxillary palp grey. Prothoracic pleura dark grey-brown, meso-thoracic antedorsum brown, paler laterally and posteriorly, dorsa grey-brown over anterior half, brown posteriorly, area between dorsa cream. Scutellum brown; metathoracic antedorsum brown, dorsa brown with black marginal sutures, area in mid-



Figures 36–40. *Caecilius juneae*. Female: 36, forewing; 37, hindwing; 38, subgenital plate; 39, gonapophyses; 40, spermapore sac. Figures 36, 37 and 38–40 to common scales.



Figures 41–43. *Caecilius juneae*. Male: 41, forewing; 42, hypandrium; 43, phallosome. Figures 42 and 43 to common scale.

line between dorsa cream; meso- and meta- thoracic pleura brown. Legs: coxa and apical tarsal segment brown, otherwise cream. Fore wing (fig. 36) with complex pattern of brown clouds and hyaline areas. Hing wing (fig. 37) pale brown, darker along anterior margin in basal half. Abdomen grey-brown dorsally, pale cream interconnecting islands indicating margins of terga; sterna grey-brown with wide pale cream bands.

Morphology. IO:D = 3.7. Clypeal shelf intermediate. Labral stylets small, spiculate; labral sensillae 5 in all; internal labral sclerotization present.

Lacinia broad, flat, expanded preapically on 1 side, with apical denticles. Vein cu_2 in fore wing setose, pterostigma with a distinct short spur vein bearing 2 setae; setae on veins *r, m+cu, an* and basal section of cu_1 in 2 ranks, remaining veins with setae in single rank. Mesothoracic precoxal suture absent. Epiproct rounded, setose. Paraprocts with oval field of 25 trichobothria and 1 seta not in rosette. Subgenital plate (fig. 38). Gonapophyses (fig. 39) with 1 or 2 setae on remnant of external valve; spermathecal sac (fig. 40) heavily sclerotised, spindle-shaped with clearly defined thick margin, spermathecal duct with obvious glandular structure over most of its length, duct in this region unsclerotised.

Dimensions. B 3.2, FW 3.80, HW 2.90, F 0.73, T 1.27, t_1 0.403, t_2 0.135, rt 3.0:1, ct 23, 0, f_1 0.651, f_2 0.391.

Description of male. Coloration (after ca 5 yr in alcohol). As female with the following exceptions: apical segment of maxillary palp dark grey, antennae brown. Prothoracic dorsa brown. Tibiae and tarsi of prothoracic legs light brown, tarsi of mesothoracic legs light brown, apical tarsal segment of hind leg light brown. Fore wing (fig. 41) generally light brown with darker brown markings, hyaline areas confined to regions of *rs-m* junction and vein cu_{1b}.

Morphology. IO:D = 1.6. Clypeus, labrum and lacinia as in female. Antenna thicker than that of female, basal flagellar segment bent. Vein cu_2 in fore wing setose, pterostigmal spur vein less distinct than in female but 2 setae present; setae of vein *r* and basal section of *an* in 2 ranks, remaining veins having setae of single rank. Mesothoracic precoxal suture as in female. Tibiae of uniform width, swellings absent. Epiproct rounded, setose. Paraproct with oval field of 32 trichobothria and more apical field of fine spinelets. Hypandrium (fig. 42) simple, setose. Phallosome (fig. 43) with penis bulb sclerotised, finely serrated.

Dimensions. B 2.3, FW 4.20, HW 2.90, F 0.77,

T 1.31, t_1 0.413, t_2 0.154, rt 2.7:1, ct 22, 0, f_1 0.738, f_2 0.479.

Etymology. This species is named after June Cheah, for her assistance with this project.

Remarks. This strikingly dimorphic species of tall open (site 7) and closed (site 8) forest differs from all others described from Australia in female wing pattern. The sexes were associated on the grounds of many instances of co-occurrence and the absence of any males with the female wing pattern and females with the male wing pattern; the head pattern with the obvious dark grey-black X sign centred on the ocellar protuberance is characteristic of both sexes.

The only other caeciliid described from Australia with a pterostigmal spur vein and vein cu_2 setose in the fore wing appears to be *Fuelleborniella parviramosa* Enderlein from Sydney, NSW. *F. parviramosa* is a much smaller species (fore wing length 2.5 mm) and the wing colour and head pattern appear to be different from *C. juneae*. The presence of ocelli, two ventral abdominal vesicles on the abdomen and 1 or 2 setae on the remnant of the external valve of the female indicate that *C. juneae* belongs within the subfamily Caeciliinae Mockford and not Fuellebornellinae Mockford.

Caecilius pteridii Smithers

Caecilius pteridii Smithers, 1977: 257.

Material examined. 41♀, 22♂, 14 nymphs: site 1 (Nov 1985), site 2 (Feb 1986), site 3 (May, Jun 1985, Jan 1986), site 4 (May, Jul, Aug, Dec 1985, Jan 1986), site 5 (Nov, Dec 1985 – nymph only, Jan 1986), site 6 (Mar, Apr, May, Jun, Jul, Nov, Dec 1985, Jan, Feb 1986), site 7 (May 1985), site 9 (Dec 1985, Jan 1986), site 10 (Mar, Nov 1985, Jan 1986), site 11 (Sep, Nov 1985 – nymph only), site 14 (Apr 1990), site 25, site site 26, site 27, site 28 (Apr 1991), site 31, site 32.

Remarks. Originally described from near Sydney, NSW, this species has since been recorded from the Bass Strait islands and Victoria. On Wilsons Promontory it was found in most habitats.

Caecilius quercus Edwards

Caecilius quercus Edwards, 1950: 131.

Material examined. 56♀, 40♂, 21 nymphs: site 8 (Jul 1985), site 10 (Mar 1985, Jan, Feb 1986), site 11 (Mar, Dec 1985, Feb 1986), site 12, site 14 (Apr 1984, Jan 1991), site 15 (Apr 1984), site 16, site 17 (Jan 1985), site 25, site 27, site 29, site 30, site 33, site 34, site 37.

Remarks. This species is known from Tasmania, the Bass Strait islands, Victoria and Lord Howe Island. It was collected in a wide variety of vegetation types.

Caecilius semifuscatus (Tillyard)

Maoripsocus semifuscatus Tillyard, 1923: 191.
Caecilius semifuscatus. — Smithers, 1969: 280.

Material examined. 133♀, 70♂, 62 nymphs: site 1 (Jan, Feb, Mar, May, Jun, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 2 (Jun, Aug, Nov 1985, Jan, Feb 1986), site 3 (Jan, Feb 1986), site 4 (Jan, Feb 1986), site 10 (Mar, Sep, Nov, Dec 1985, Jan, Feb 1986), site 11 (Nov 1985, Feb 1986), site 14 (Apr 1984, Apr 1990), site 15 (Apr 1984), site 20, site 21, site 22, site 23, site 26, site 29, site 30, site 31, site 32, site 33, site 36, site 40.

Remarks. C. semifuscatus, originally described from New Zealand, is known from the Bass Strait islands, Victoria and South Australia. It was never collected in open or closed forest in this survey, but occurred predominantly in coastal vegetation of various types.

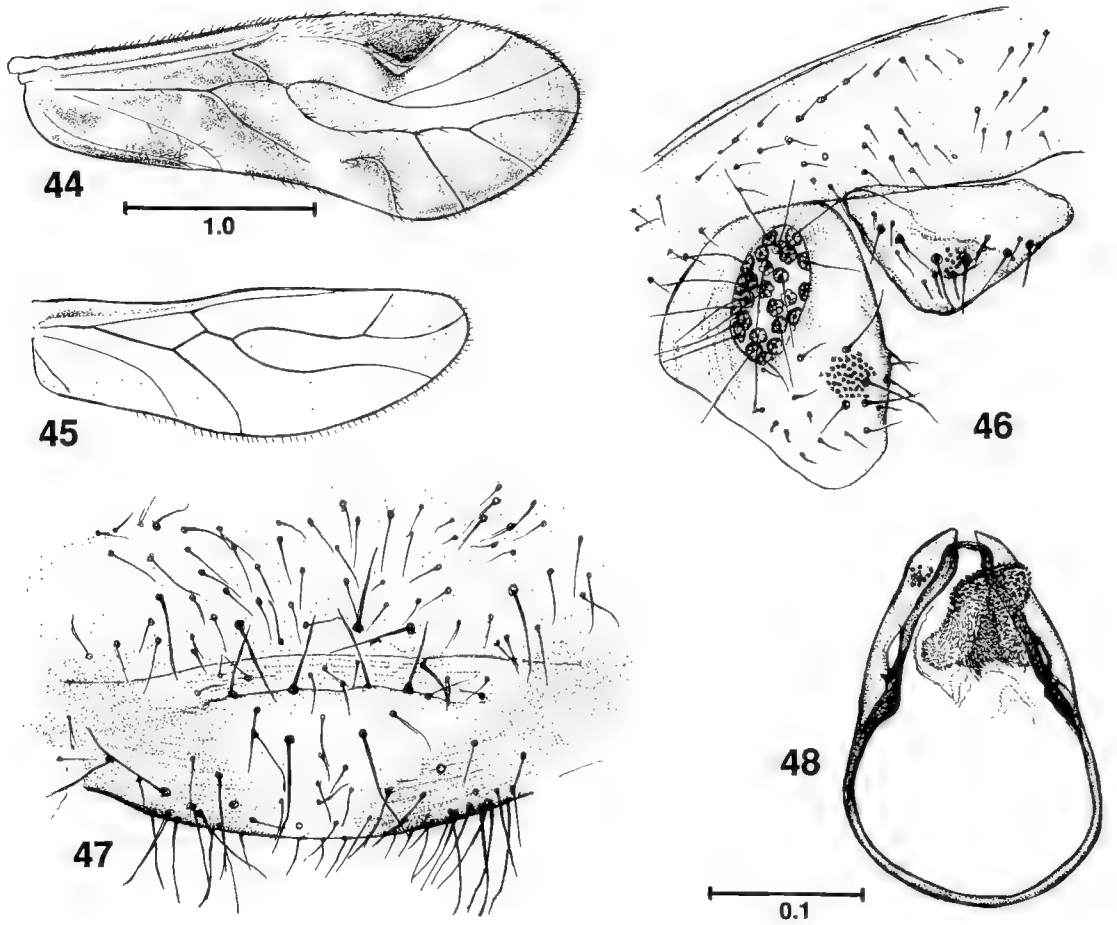
Caecilius wilsoni sp. nov.

Figures 44–48

Material examined. Holotype ♂: Lilly Pilly Nature Track, tall open forest, 21–23 Feb 1986 (K73445).

Description of male. Coloration (after ca 4 years in alcohol). Head generally pale buff. The following are brown: posterior vertex, a broad band each side of epicranial suture, narrow band bordering orbit, frons, striae on postclypeus, antenna. Gena pale brown, maxillary palp dark brown, ocellar protuberance dark brown, bordered brown, eyes dark grey. Thoracic terga brown, scutella dark brown, their marginal sutures black; a pale buff area just anterior to prothoracic scutellum; thoracic pleura brown. Legs: coxa and tarsal segments brown, tibia light brown at basal and distal ends, legs otherwise pale buff. Fore wing (fig. 44) patterned with hyaline areas and shades of brown from pale to mid brown (pterostigma). Hind wing (fig. 45) pale brown, costal cell darker. Abdomen pale buff.

Morphology. IO:D = 0.8. Clypeal shelf intermediate. Labral stylets small, spiculate; labral sensillae 5 in all; internal labral sclerotization present. Lacinia broad, flat, expanded preapically on 1 side, with apical denticles. Basal flagellar segment not enlarged or bent. Vein cu_2 of fore wing setose. Mesothoracic precoxal suture absent. Tibiae of uniform width, swellings absent. Epiproct (fig. 46). Paraproct (fig. 46) with an oval field of 27 trichobothria and a dis-



Figures 44–48. *Caecilius wilsoni*. Male: 44, forewing; 45, hindwing; 46, epiproct and paraproct; 47, hypandrium; 48, phallosome. Figures 44, 45 and 46–48 to common scales.

tinct field of small papillae. Hypandrium (fig. 47) simple, setose. Phallosome (fig. 48).

Dimensions. B 2.0, FW 2.90, HW 2.27, F 0.57, T 0.87, t_1 0.260, t_2 0.120, rt 2.1:1, ct 23, 0, f_1 0.513, f_2 0.339.

Female. Unknown.

Remarks. This rare species, described from a single male, is clearly related to *Caecilius semifuscatus*, which is common, and *C. fastigatus* Smithers, from New Zealand. *C. fastigatus* differs from both in head pattern, having an ivory vertex on an otherwise very dark brown head. *C. semifuscatus* and *C. wilsoni* differ in details of fore wing pattern.

Enderleinella Badonnel

Enderleinella Badonnel, 1932: 77. Type species: *Caecilius perlatus* Kolbe.

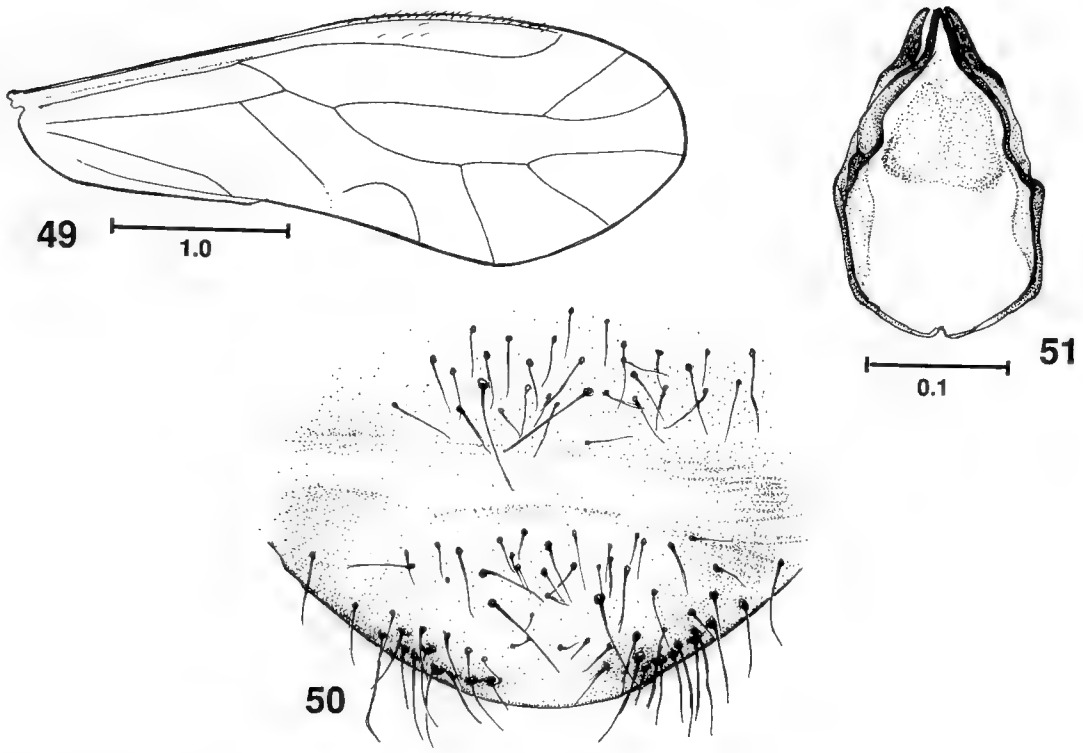
Enderleinella hilli Smithers

Figures 49–51

Enderleinella hilli Smithers, 1979: 62.

Material examined. Specimen on which description based: ♂, Lilly Pilly Nature Track, 'The Loop', closed forest, 29 Sep–1 Oct 1985. Additional records (327♀, 272♂, 210 nymphs): site 2 (Dec 1985, Feb 1986), site 4 (Jan 1986), site 5 (Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 6 (Jan 1986), site 7 (Sep, Oct, Nov, Dec 1985, Jan 1986), site 8 (Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan 1986), site 9 (Jan, Feb 1986), site 10 (Dec 1985, Jan, Feb 1986), site 11 (Aug, Nov, Dec 1985, Jan, Feb 1986), site 19, site 25, site 26, site 28 (Apr 1990, Apr 1991), site 29, site 30, site 38, site 39.

Description of male. Coloration (after ca 5 yr in alcohol). As female with the following exceptions: scape, pedicel and apical 4 segments of flagellum pale brown, remainder brown; tibia



Figures 49–51. *Enderleinella hilli*. Male: 49, forewing; 50, hypandrium; 51, phallosome. Figures 50 and 51 to common scale.

and tarsus of prothoracic leg pale brown, thoracic terga mid brown.

Morphology. IO:D = 0.5. Fore wing (fig. 49). Epiproct semicircular, membranous. Paraproct with an oval field of 22 trichobothria. Hypandrium (fig. 50) with rounded posterior margin, setose except posteromedially. Phallosome (fig. 51).

Dimensions. B 2.3, FW 3.75, HW 2.77, F 0.72, T 1.23, t_1 0.395, t_2 0.118, rt 3.3:1, ct 28, 0, f_1 0.727, f_2 0.656.

Remarks. This species was described from Tasmania from a single female. The sclerotised area of the paraproct mentioned by Smithers (1979) is also distinguishable in the male. The species was collected quite frequently during summer months in almost all vegetation types.

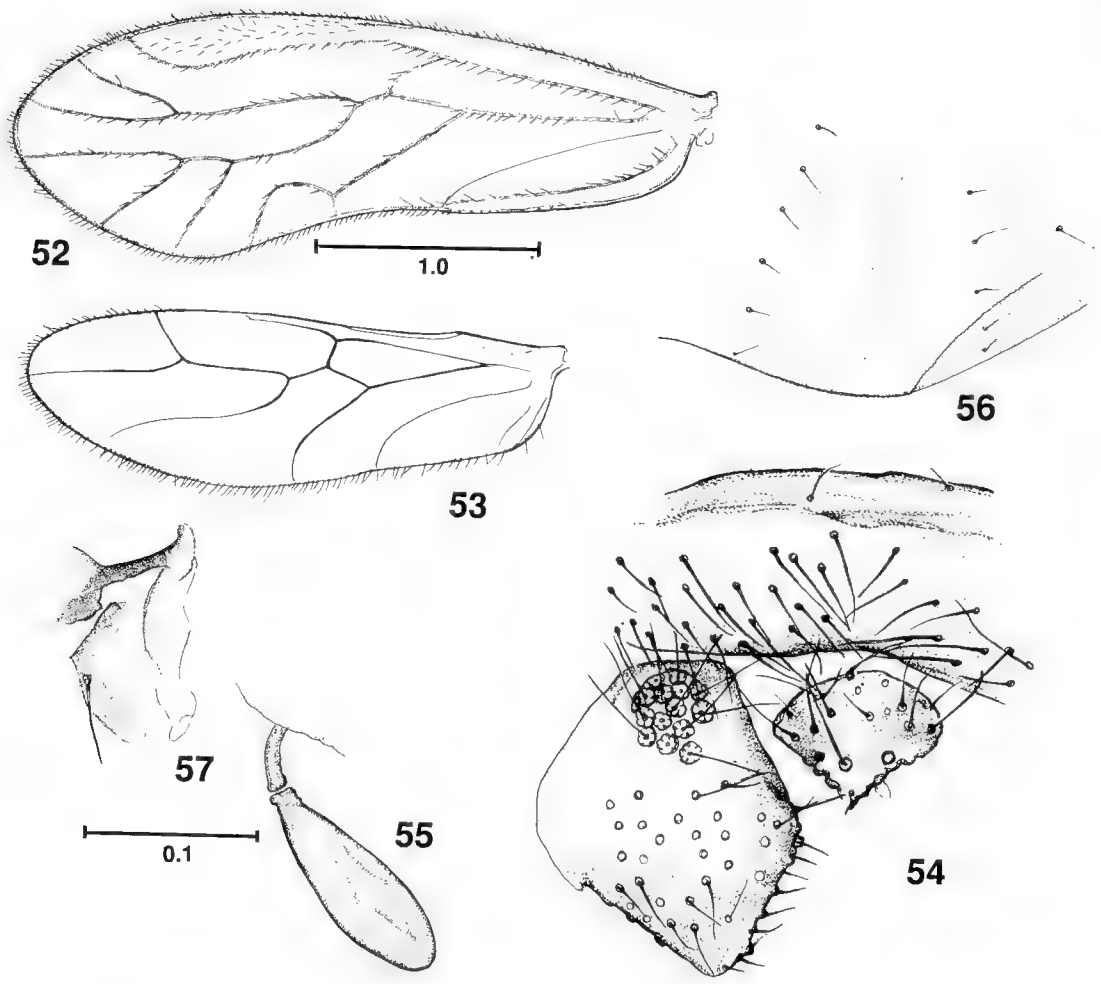
Enderleinella selta sp. nov.

Figures 52–61

Material examined. Holotype ♀: Waterpump shed, *Melaleuca ericifolia* scrub, 8–10 Sep 1985; allotype ♂, 46 nymphs, 113♀ and 63♂ paratypes: same data as holotype (K73446–K73623). Additional records (574♀, 769♂, 312 nymphs): site 1 (Dec 1985, Jan 1986), site 2 (May, Sep, Nov, Dec 1985, Jan, Feb 1986), site 3 (Mar, Apr, May, Jun, Jul, Aug, Nov, Dec 1985, Jan, Feb 1986), site 4 (Mar, Dec 1985, Jan, Feb 1986), site 5 (Jan, Jun, Sep, Nov, Dec 1985, Jan, Feb 1986), site 6 (Dec 1985, Jan, Feb 1986), site 8 (Jul, Dec 1985, Jan 1986), site 9 (Mar, Sep, Nov, Dec 1985, Jan 1986), site 9 (Mar, Sep, Nov, Dec 1985, Jan, Feb 1986), site 11 (Jan 1985), site 14 (Apr 1984), site 15 (Apr 1984), site 16, site 20, site 22, site 26.

Description of female. Coloration (after ca 5 yr in alcohol). Body generally pale buff with the following exceptions: a suggestion of greyish coloration between eyes, on postclypeal striae and stirrup mark on frons. Median epicranial suture and setae dark brown. Ocellar protuberance pale, ocelli pale. Eyes black. Gena cream. Apical segment of maxillary palp greyish in apical half. Basal flagellar segment pale brown, rest of flagellum brown. Prothoracic nota light brown, apical tarsal segment greyish. Abdomen cream. Fore wing (fig. 52) hyaline with a faint brownish tinge, slightly darker in anal cell. Hind wing (fig. 53) hyaline.

Morphology. IO:D = 1.5. Anterior margin of labrum sclerotised. Epiproct (fig. 54). Paraproct (fig. 54) with oval field of 16 trichobothria, scler-



Figures 52–57. *Enderleinella selta*. Female: 52, forewing; 53, hindwing; 54, epiproct and paraproct; 55, spermapore sac; 56, subgenital plate; 57, gonapophyses. Figures 52, 53 and 54–57 to common scales.

ification similar to *E. hilli*, bifid cone present posteriorly with seta through middle. Spermatheca (fig. 55). Subgenital plate (fig. 56) simple, setose. Gonapophyses (fig. 57) as 2 membranous lobes, 1 bearing a single seta.

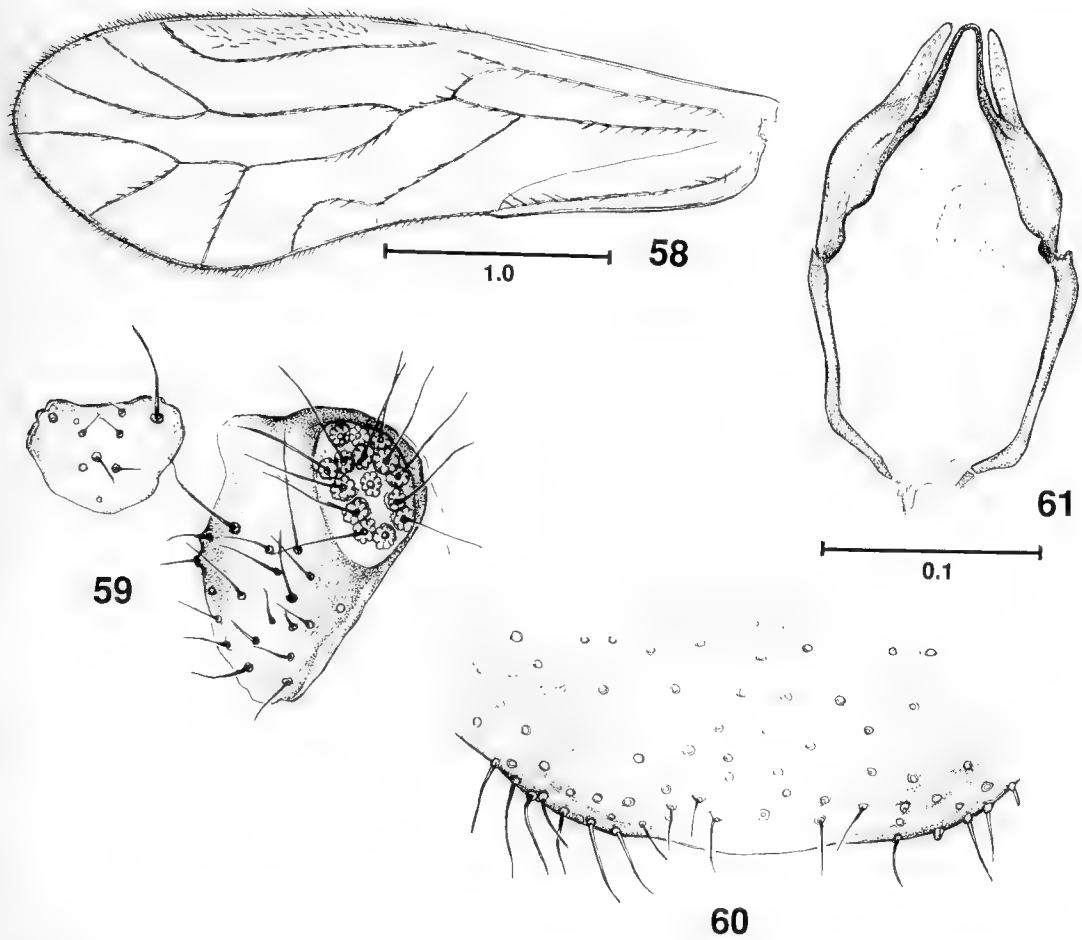
Dimensions. B 2.3, FW 3.10, HW 2.42, F 0.61, T 1.04, t_1 0.332, t_2 0.134, rt 2.5:1, ct 19, 0, f_1 0.499, f_2 0.384.

Description of male. Coloration (after ca 5 years in alcohol). As female with following exceptions: flagellum and mesothoracic nota brown, metathoracic nota light brown. Fore wing (fig. 58) very pale brown.

Morphology. IO:D = 1.0. Antenna generally as female but flagellum thicker, longer. Epiproct (fig. 59) semi-circular. Paraproct (fig. 59) with oval field of 13-16 trichobothria. Hypandrium (fig. 60) simple, posterolateral margin setose, sclerotised. Phallosome (fig. 61) angular, outer parameres broad at base, tapering to apex.

Dimensions. B 2.0, FW 3.21, HW 2.51, F 0.63, T 1.11, t_1 0.356, t_2 0.126, rt 2.8:1, ct 23, 0, f_1 0.730, f_2 0.605.

Remarks. Like the previous species, *E. selta* is widely distributed on Wilsons Promontory. Three Australian species of *Enderleinella* and one New Zealand species are closely similar in morphology and general colour. *E. selta* is consistently smaller than the other species, the sympatric *E. hilli*, *E. globiclypeus* (Enderlein), which has a more northerly distribution in Australia, and *E. zelandica* (Tillyard) (New Zealand). As



Figures 58–61. *Enderleinella selta*. Male: 58, forewing; 59, epiproct and paraproct; 60, hypandrium; 61, phallosome. Figures 59–61 to common scale.

pointed out by Smithers (1979) the ventral valve of the female gonapophyses of *E. hilli* (length about twice width) is a different shape from those of *globiclypeus* and *zelandica* (length about 4 times width). *E. selta* conforms with the last two species in this character.

E. hilli and *E. selta*, as is often the case with closely similar species, are not difficult to distinguish when seen together. *E. selta* is smaller, the setae on the fore wing veins more prominent, and the general colour more buff than pale cream as in *E. hilli*.

Amphipsocidae Pearman

Taeniostigma Enderlein

Taeniostigma Enderlein, 1901: 546. Type species: *Psocus elongatus* Hagen.

Taeniostigma trickettae Smithers

Taeniostigma trickettae Smithers, 1974: 211.

Material examined. 10♀, 1♂, 24 nymphs: site 5 (Jan 1985), site 7 (Sep, Oct, Dec 1985, Jan 1986), site 8 (Nov, Dec 1985, Jan, Feb 1986), site 28 (Apr 1990), site 38 (nymph only).

Remarks. This species of closed (site 8) and tall (site 7) open forest is also found in other areas of Victoria, NSW and southern Queensland.

Ectopsocidae Roesler

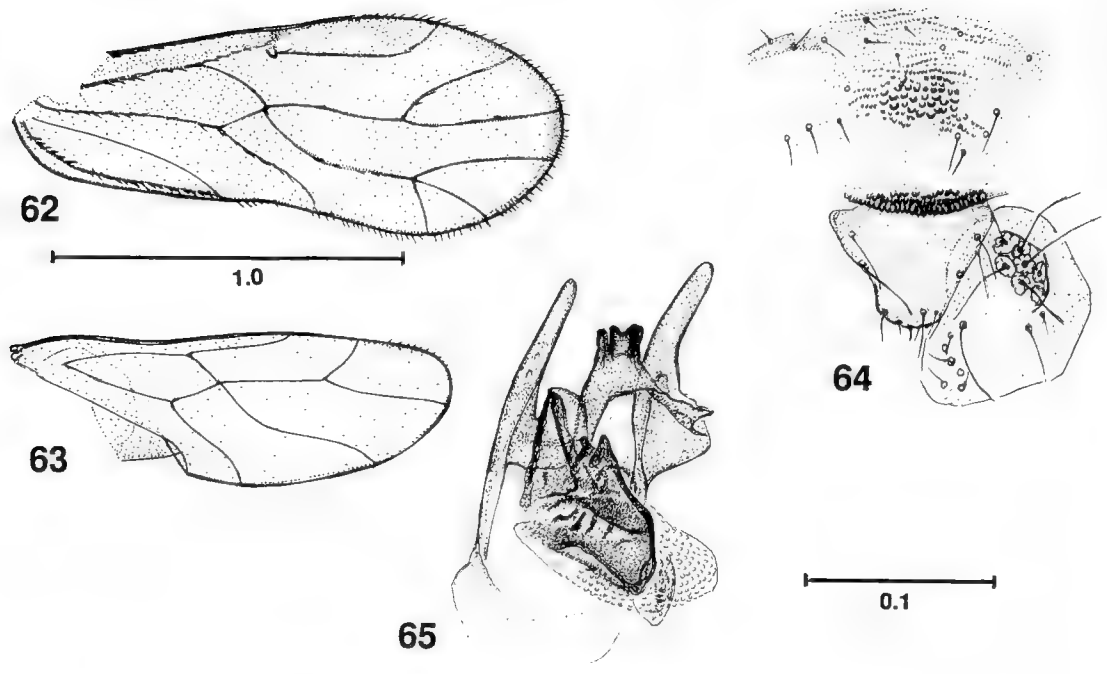
Ectopsocus McLachlan

Ectopsocus McLachlan, 1899: 277. Type species: *Ectopsocus briggsi* McLachlan.

Ectopsocus acutistigma sp. nov.

Figures 62–69

Material examined. Holotype ♂: Lilly Pilly Nature Track, heath, 12–15 Mar 1985; allotype ♀, 2♂ paratypes: same locality as holotype, 23–26 Jun 1985 (K73624–K73627). Additional record (1♂): site 7 (Mar 1985).



Figures 62–65. *Ectopsocus acutistigma*. Male: 62, forewing; 63, hindwing; 64, epiproct, paraproct and ninth tergite; 65, phallosome. Figures 62, 63 and 64, 65 to common scales.

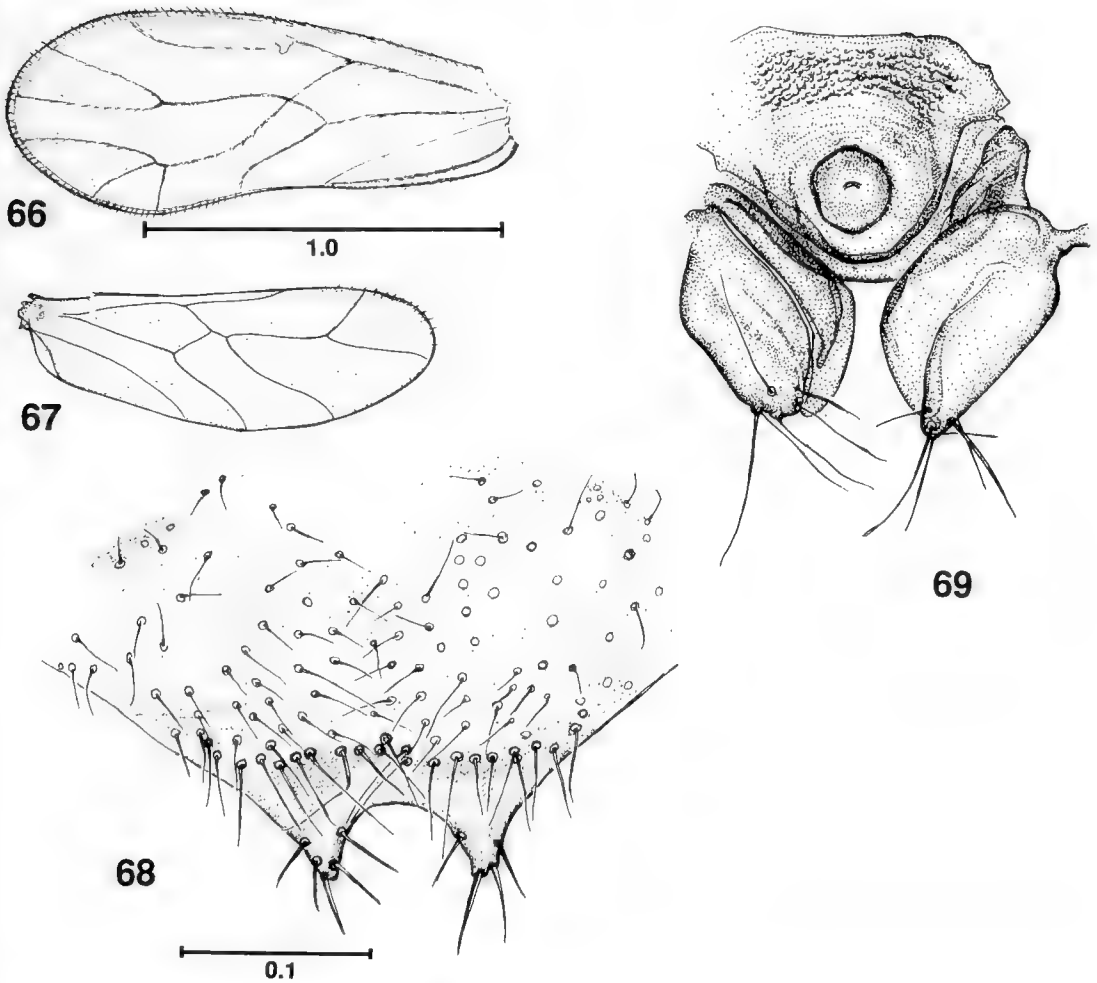
Description of male. Coloration (after ca 5 yr in alcohol). Body color generally pale buff with following exceptions: eyes black, ocelli with black centripetal margins, usual vertex marks pale brown, postclypeus with pale brown striae, abdomen with grey-brown granulations. Fore wing (fig. 62) uniformly suffused very pale brown. Hind wing (fig. 63) paler.

Morphology. IO:D = 6.0. Antenna slightly thicker than in female. In fore wing (fig. 62), veins *rs* and *m* meet at a point, veins m_2 and m_3 originate very close to one another (in 1 wing at a tripartite junction with m_1); pterostigma long, r_1 meets costa at an acute angle; veins with single row of small setae. In hind wing (fig. 63) veins *rs* and *m* connected by short cross vein in 1 wing, by short fusion in the other; wing devoid of setae apart from 12 setae on costa between termination of r_{2+3} and r_{4+5}. Flagellar segments thick, with setae of greater length than thickness of flagellum. Epiproct (fig. 64). Paraproct (fig. 64) with oval field of 7 or 8 trichobothria. Ninth tergite (fig. 64) with clunial comb of blunt teeth in 3 ranks, anterior rank sparse and teeth low; more anteriorly a field of broad, rounded low tubercles. Hypandrium simple, setose. Phallosome (fig. 65) with large penial bulb sclerites; apex of inner parameres fused into a bilobed terminal process between a pair of short, rounded terminal prongs.

Dimensions. B 1.5, FW 1.62, HW 1.30, F 0.14, T 0.22, t_1 0.174, t_2 0.087, rt 2.0:1, ct 12, 0, f_1 0.237, f_2 0.130.

Description of female. Coloration (after ca 5 yr in alcohol). As male, but scape, pedicel, tibia and tarsus pale brown.

Morphology. IO:D = 6.5. In fore wing (fig. 66), as in male, veins m_2 and m_3 originate close together and m_1 is long; veins *rs* and *m* fused for a very short distance or meet in a point; pterostigma and ciliation as male. Hind wing (fig. 67) veins *rs* and *m* fused for a distance (both wings), wing bare apart from 3 marginal setae between termination of r_1 and r_{2+3} and 9 between r_{2+3} and r_{4+5}. Flagellum more slender than that of male, length of setae up to twice thickness of flagellar segments. Epiproct similar to that of male; paraproct with oval field of 7 or 8 trichobothria. Subgenital plate (fig. 68) apical lobes with 5 and 4 stout marginal setae. Gonapophyses (fig. 69) with 3 distinct valves, dorsal and ventral valves



Figures 66–69. *Ectopsocus acutistigma*. Female: 66, forewing; 67; hindwing; 68, subgenital plate; 69, gonapophyses and spermapore plate. Figures 66, 67 and 68, 69 to common scales.

very finely spiculate, outer valves with 6 and 7 terminal setae. Spermapore plate (fig. 69) with distinct concentric pattern of sclerotisation and anterior rugose area.

Dimensions. B 1.3, FW 1.45, HW 1.15, F 0.35, T 0.41, t_1 0.144, t_2 0.077, rt 1.9:1, ct 12, 0, f_1 0.197, f_2 0.103.

Remarks. This appears to be a forest species.

In the shape of the pterostigma *E. acutistigma* most resembles *Ectopsocus ornatus* Smithers and Thornton from Norfolk Island, which it also resembles in features of male and female genitalia. *E. acutistigma* can be distinguished, however, by the plain wing lacking terminal vein spots, the details of the fusion of the inner parameres of the phallosome and the multiple-ranked comb of the male clunium. A feature of this species is the venation of the wings — in none of the five specimens is *rs* and *m* in the fore wing joined by a cross vein, in all of them veins m_2 and m_3 originate close together and veins *rs* and *m* in the hind wing are fused, the length of fusion being greater in males. *Ectopsocus axillaris* (Smithers), also found at Wilsons Promontory (as well as New Zealand), has similar venational peculiarities apart from the pterostigma and the relationship between veins m_1, m_2, and m_3. It can be distinguished from *E. acutistigma* by the non-uniformly pigmented fore wing and by the very dark brown head and thorax. In *Ectopsocus brunneus* (Edwards), which also has veins *rs* and *m* fused in the hind wing, the female fore wing has small spots at the apices of the veins, and the ocellar tubercle is black; the colour pattern of the head and thorax

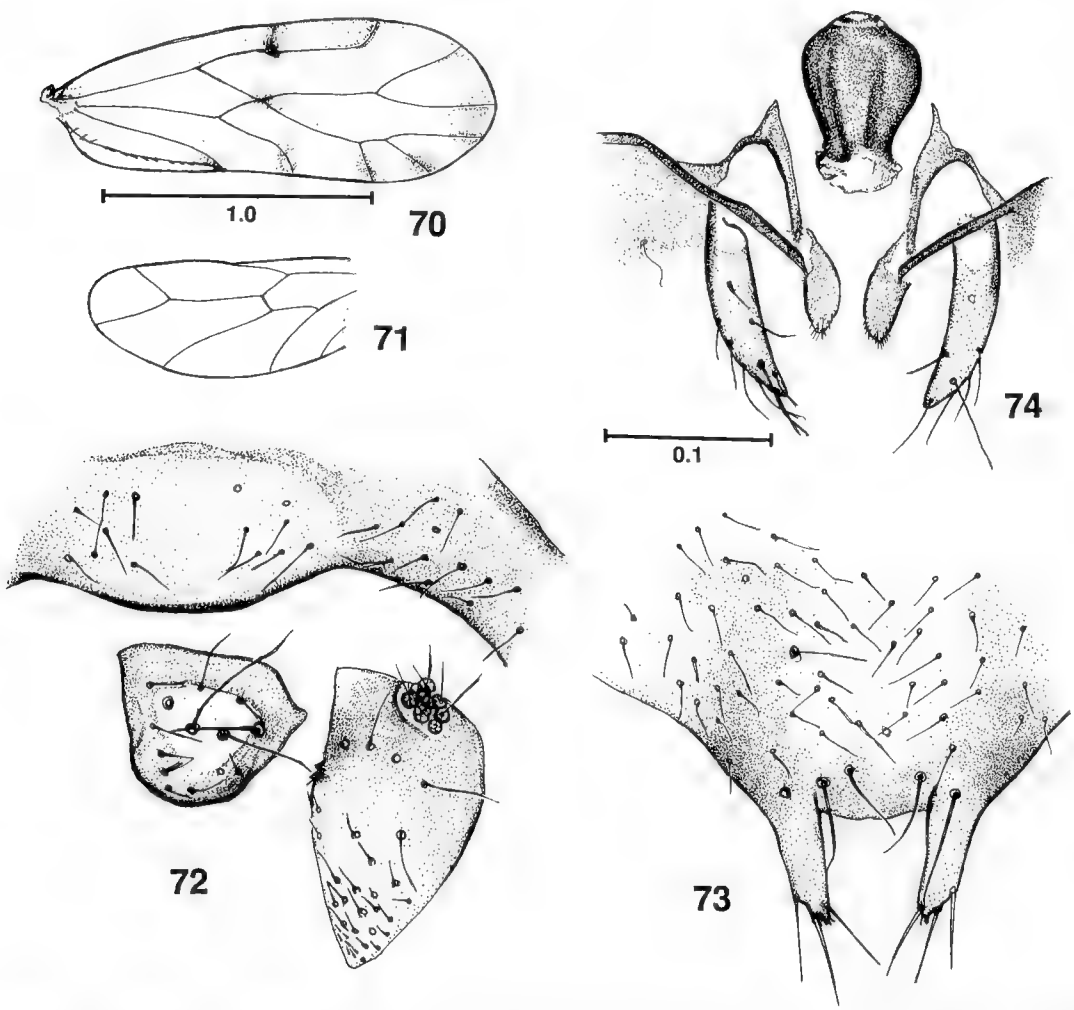
is also quite distinct from the uniformly pale head of *E. acutistigma*.

Ectopsocus australis sp. nov.

Figures 70–79

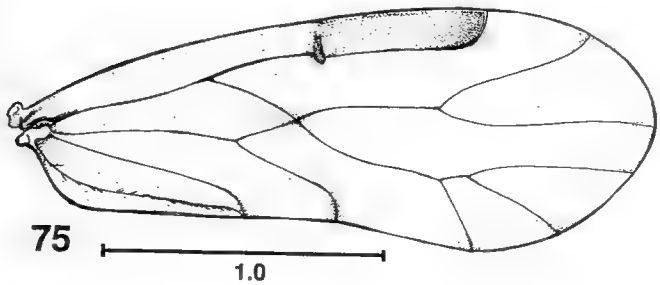
Material examined. Holotype ♀: Lilly Pilly Nature Track – 'The Loop', closed forest, 15–16 Dec 1985; allotype ♂, 1 nymph, 7♀ and 8♂ paratypes: same data as holotype (K73628–K73644). Additional records (90♀, 29♂, 12 nymphs): site 5 (Sep 1985), site 7 (Mar, Nov 1985, Jan, Feb 1986), site 8 (Jan, Feb, Mar, Apr, May, Jun, Aug, Sept, Oct, Nov 1985, Jan, Feb 1986, Jan 1991), site 9 (May 1985), site 10 (Dec 1985), site 11 (Dec 1985), site 12, site 14 (Jan 1991), site 19, site 25, site 28 (Apr 1990, Apr 1991), site 29, site 32, site 38, site 44.

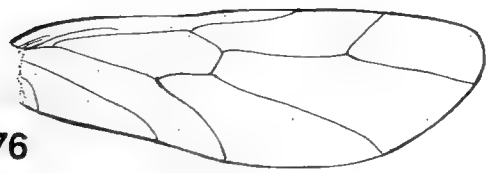
Description of female. Coloration (after ca 5 yr in alcohol). Head buff with vertex marks (as large pigment patches), triangular frons mark, postclypeal striae, and line from antennal socket to orbit, brown. Gena and maxillary palp very pale buff, apical segment of palp slightly greyish. Scape and pedicel light brown, flagellum buff. Eyes black. Ocelli pale, their surrounds pale. Thoracic terga brown with paler margins, a dark brown line along cervicum and side of thorax, legs very pale buff. Fore wing (fig. 70) membrane greyish, a little paler near margin, with 10 distinct spots at ends of veins and *rs-m* junction. Hind wing (fig. 71) hyaline. Abdomen pale buff with dark grey-brown pigment on dorsolateral areas of terga.

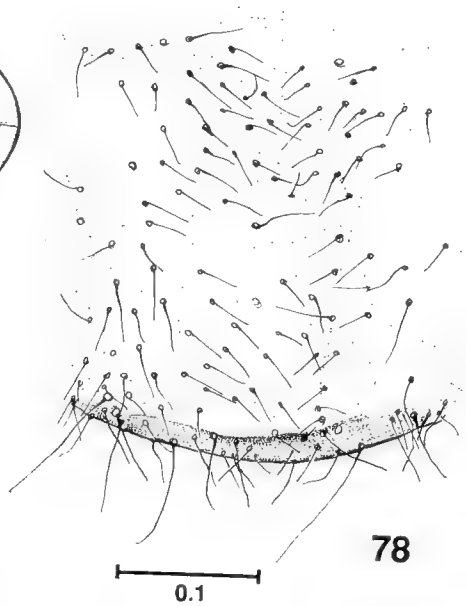


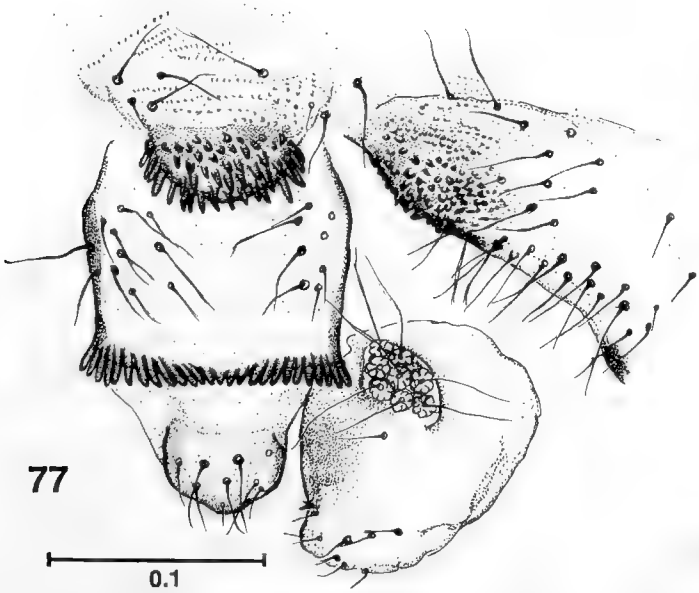
Figures 70–74. *Ectopsocus australis*. Female: 70, forewing; 71, hindwing; 72, epiproct and paraproct; 73, subgenital plate; 74, gonapophyses and spermathecal sac. Figures 70, 71 and 72–74 to common scales.

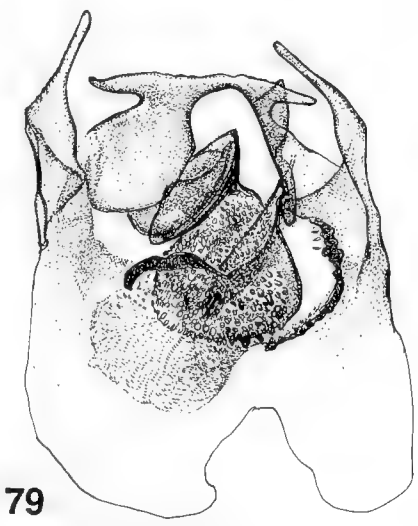
Morphology. IO:D = 8.5, eyes small. Epiproct (fig. 72) setose. Paraproct (fig. 72) with field of 9 trichobothria and pair of spines of unequal length (and 1 associated seta) joined approximately third length of largest spine from base. Subgenital plate (fig. 73) setose with transverse row of 6 large setae near apical margin of disc (1 socket displaced during preparation), central apical margin of disc with pigmented area bearing very fine spicules near midline; apical lobes fairly straight and separated from disc by a suture basally, apically with 3 stout setae, between inner pair a spiculate projection; disc heavily sclerotised laterally as basal continuation of apical lobes. Gonapophyses (fig. 74): outer valves curved toward midline, bearing 7–9 setae, apices finely spiculate, valves at least twice as large as dorsal valves, which are short, broad, tapering to spiculate apices; ventral valves long, narrow, spiculate; spicules on dorsal valve longer than those of other valves. Between ventral valves a large sclerotised 'spermathecal











Figures 75–79. *Ectopsocus australis*. Male: 75, forewing; 76, hindwing; 77, epiproct, paraproct and ninth tergite; 78, hypandrium; 79, phallosome (paratype). Figures 75, 76 and 77 and 79 to common scales.

sac' (fig. 74) similar in shape and structure to that described by Mockford (1959) for *Ectopsocus californicus* (Banks).

Dimensions. B 1.65, FW 1.62, HW damaged, FW 0.38, T 0.63, t_1 0.190, t_2 0.087, rt 2.2:1, ct 12, 0, f_1 0.292, f_2 0.170.

Description of male. Coloration (after ca 5 yr in alcohol). Head pattern as female but overall darker; area between ocelli brown, an isolated paler area posterior to this with appearance of a fourth ocellus. Thoracic terga brown with paler margins, sides of thorax brown. Dark line along cervicum not extending to thorax. Fore wing (fig. 75) generally as female but spots at apices of veins near wing apex not well marked (6 distinct spots, 2 indistinct). Hind wing (fig. 76) hyaline. Legs and abdomen as female.

Morphology. IO:D = 3.5, eyes fairly large. Fore wing larger than female, flagellum thicker. Epiproct (fig. 77) setose. Paraproct (fig. 77) with field of 9 trichobothria, duplex spines and associated seta as female. Ninth tergite (fig. 77) with apical comb of long rounded teeth, shorter and directed towards midline over central section. Apex of eighth tergite with semicircular field of thick blunt spines, long apically and progressively shorter basally. An ill-defined field of spines on ninth sternite lateral to the field on the eighth tergite. Hypandrium (fig. 78) with slightly curved, somewhat sclerotised apical margin. Phallosome (fig. 79 – paratype) very similar to that of *Ectopsocus punctatus* Thornton and Wong, with a single 'thimble' structure near apex of fused inner parameres.

Dimensions. B 1.45, FW 2.21, HW 1.71, F 0.41, T 0.72, t_1 0.245, t_2 0.091, rt 2.7:1, ct 15, 0, f_1 0.375, f_2 0.253.

Remarks. Taken predominantly in closed forest (site 8), the species was also found in open forest (sites 7, 9 and 19) and closed scrub.

There are five described species of the *briggsi* group of *Ectopsocus* with a hyaline fore wing having dark spots at the apices of the veins and at the *rs-m* junction: *E. briggsi* McLachlan, *E. californicus* (Banks), *E. froggatti* Enderlein, *E. meridionalis* Ribaga and *E. punctatus* Thornton and Wong [*E. congener* Tillyard was placed in synonymy with *E. californicus* by Smithers (1969)]. *E. meridionalis* is known only from the female and is parthenogenetic. Jentsh (1939) clearly demonstrated differences between *E. briggsi* and *E. meridionalis*, which were supported in part by Badonnel (1943). The type (female) of *E. froggatti* is unavailable (lost), but Edwards (1950) described a common species from Tasmania that he identified with *E. froggatti*, including descriptions of both sexes. The following references are thus to *E. froggatti* (*sensu* Edwards). Mockford (1959) treated the *briggsi* complex of North and South America, noting and illustrating differences between *E. briggsi, E. californicus* and *E. meridionalis*. In describing *E. punctatus*, Thornton and Wong (1968) noted its resemblance to both *E. briggsi* and *E. froggatti*, but pointed out differences from these species; the holotype female and male allotype of this New Zealand species have been re-examined.

Ectopsocus australis differs from the following in having a subgenital plate in which the apical lobes are separated from the main plate by a suture which appears to be a continuation of the mesial margin of each lobe: *briggsi, californicus, punctatus* and *rileyae* (below). It differs from the following in that between the terminal setae of the apical lobes of the subgenital plate there is a small but distinct projection: *californicus, froggatti* and *rileyae*. In *briggsi* and *punctatus* this projection is smoothly rounded apically; in *meridionalis* and *australis* it is spiculate. Enderlein (1906) noted that a diagnostic feature of *E. froggatti* was the head pattern, consisting of small dark spots as previously figured by him under the name *E. briggsi* (Enderlein, 1903: pl. VII fig. 47). Edwards (1950: 128) noted this feature in his description of Tasmanian specimens that he assigned to *froggatti*. The specimens from Wilsons Promontory lack such a pattern. In the possession of a massive, characteristically-shaped sclerotisation associated with the female gonopore, *australis* resembles only *E. californicus*; the other five species lack this structure. The spine on the edge of the paraproct of *californicus* is single, in *briggsi* and *froggatti* it is a duplex spine, incompletely divided, with each member of the pair of similar size; in *meridionalis* there is a similar duplex spine with one member of the pair much larger than the other. The paraproct of *australis, punctatus* and *rileyae* has two adjacent but almost separate spines. The phallosome of *australis* most closely resembles that of *punctatus* and *rileyae* in the possession of one thimble-like structure towards the apex of the frame; in *briggsi* there is a pair of thumb-like structures, and *californicus* and *froggatti* evidently lack any such structures. The ornamentation of the eighth tergite of *australis* again resembles that of *punctatus* as well as *californicus*; a fairly extensive field of strong spines is present. In *briggsi* there is but a single row of

Table 3. Features distinguishing seven species of *Ectopsocus* which have clear fore wings with spots at the ends of veins and at the *rs-m* junction.

	Female subgenital plate						
	Apical lobes separated from disc by suture	Shape of apical lobes	Projection between distal setae of apical lobe	Paraproct spines	Spermathecal sac	Phallosome 'thimble' structures	Spines of eighth tergite
E. australis	yes	straight	spiculate	duplex, unequal, adjacent	yes	single	field
E. briggsi	no	curved	smooth	duplex, equal	no	pair	row
E. californicus	no	straight	absent	single	yes	absent	field
E. froggatti	yes	straight	absent	duplex, equal	no	absent	row/field
E. meridionalis	yes	straight	spiculate	duplex, unequal	no	male unknown	male unknown
E. punctatus	no	curved	smooth	duplex, unequal, adjacent	no	single	field
E. rileyae	no	straight	absent	duplex, unequal, adjacent	no	single	absent

spines (Badonnel, 1943), and from Edwards' figure of what he identified as *froggatti* there appears to be a row of spines bordering a more distal field of smaller spines. Thus *E. australis* has features (listed above) that are similar to one or more of the other six species, except *E. briggsi* (summarised in Table 3).

E. australis shows remarkable sexual dimorphism in general colour, in the absence of the lateral thoracic stripe in the male and the very much larger male wings. We have associated the sexes on the basis of finding them together in 11 collections from 13 localities, and in never finding females similar to the males nor males similar to the females in these collections.

Ectopsocus axillaris (Smithers)

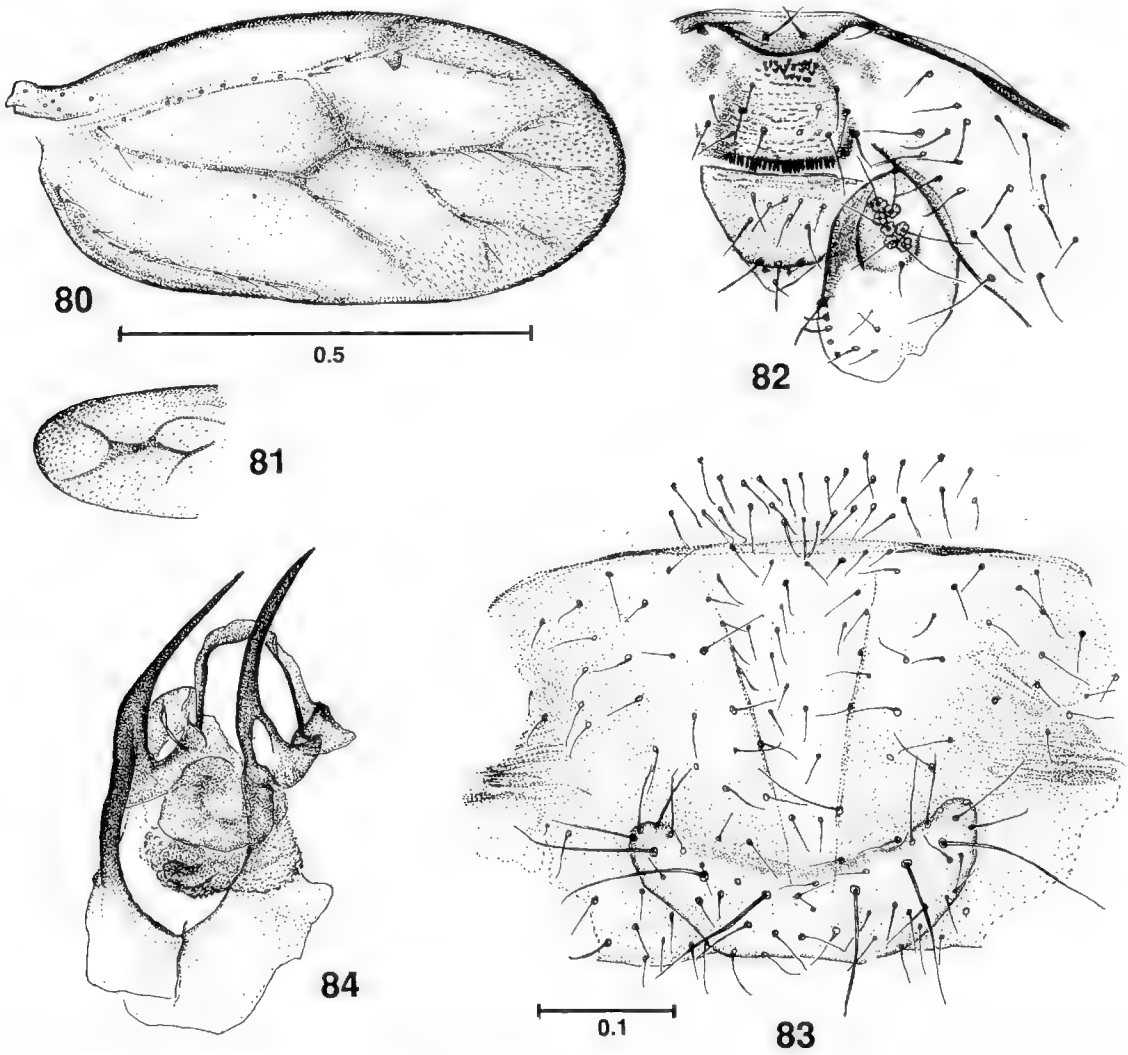
Figures 80–84

Interpsocus axillaris Smithers, 1969: 293.
Ectopsocus axillaris. — New, 1973b: 348.

Material examined. Specimen on which description based: ♂, Little Waterloo Bay, *Acmena smithii*, 27 Apr 1989. Additional records (14♀, 3♂): site 8 (Sep, Oct, Dec 1985, Jan 1986), site 25.

Description of male. *Coloration* (after ca 1 yr in alcohol). As female except thorax somewhat less dark.

Morphology. IO:D = 5.5 (IO:D = 5.5 for ♀ by Pearman's method; see Ball, 1943). Head



Figures 80–84. *Ectopsocus axillaris*. Male: 80, forewing; 81, hindwing; 82, epiproct, paraproct and ninth tergite; 83, hypandrium; 84, phallosome. Figures 80, 81 and 82–84 to common scales.

shining. Fore wing (fig.80), brachypterous. Hind wing (fig. 81). Epiproct (fig. 82) trapezoid with group of 8 setae over basal half, a transverse row of 3 setae in apical third and 3 much smaller setae near apex; basal margin with 2–3 rows of very fine spicules. Paraproct (fig. 82) with 7 trichobothria and 1 seta not in rosette, duplex spines only slightly larger than setal boss, spines divided only in apical third, each member of pair same size. Ninth tergite (fig. 82) with transverse apical comb of 1 row of long narrow teeth, in apical half with rows of spicules larger than those of epiproct; basally with field of broad irregular short spines of various sizes, no ornamentation lateral to this. Hypandrium (fig. 83 with apex folded towards anterior) with subapical transverse row of 6 very long setae, apical margin slightly concave. Phallosome (fig. 84): phallic frame broad anteriorly with median line of fusion, outer parameres projecting posteriorly as long, sharp, curved spines; fusion of inner parameres without lateral horns, large phallosome sclerites.

Dimensions. B 1.5, FW 0.71, HW damaged, F 0.38, T 0.61, t_1 0.197, t_2 0.083, rt 2.37:1, ct 8, 0, f_1 0.265, f_2 0.170.

Remarks. We provide a description of the male of this species, hitherto only known from the female. Found only in closed forest and on *Acmena smithii*, the species was not previously recorded in Australia. It was described from three macropterous females from New Zealand. Both macropterous and brachypterous females have been collected at Wilsons Promontory.

Ectopsocus briggsi McLachlan

Ectopsocus briggsi McLachlan, 1899: 277.

Material examined. 114♀, 5♂, 3 nymphs: site 5 (Sep 1985), site 7 (Feb, Sep, Oct 1985), site 8 (Sep, Oct, Nov 1985), site 9 (Nov 1985), site 11 (May 1985), site 24, site 38.

Remarks. This cosmopolitan species, collected here from forest, closed heath and scrub, and from *Banksia serrata*, is known from Norfolk Island, the Bass Strait islands and Victoria.

Ectopsocus californicus (Banks)

Peripsocus californicus Banks, 1903: 237.
Ectopsocus californicus. — Peck, 1951: 413.

Material examined. 22♀, 16♂, 1 nymph: site 11 (Mar 1985, Jan, Feb 1986), site 12, site 14 (Apr 1990, Jan 1991), site 34.

Remarks. Australian records of this species include NSW, Victoria, Tasmania and South Australia.

Ectopsocus edwardsi New

Ectopsocus edwardsi New, 1973b: 347.

Material examined. 204♀, 48♂, 11 nymphs: site 1 (Jan 1986), site 2 (Feb, Mar, Nov 1985), site 9 (Feb, Mar, May, Nov 1985, Feb 1986), site 10 (Dec 1985), site 11 (Feb, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 27, site 30, site 32.

Remarks. E. edwardsi, originally described from Wilsons Promontory, is only known from Victoria. Micropterous, brachypterous and macropterous females and males were collected here, chiefly from *Banksia serrata* (site 11), but also from coastal vegetation and low eucalypt woodland.

Ectopsocus pteridii Smithers

Ectopsocus pteridii Smithers, 1977: 265.

Material examined. 29♀, 11♂, 1 nymph: site 8 (Mar, Nov 1985, Jan, Feb 1986, Jan 1991), site 28 (Apr 1990), site 42.

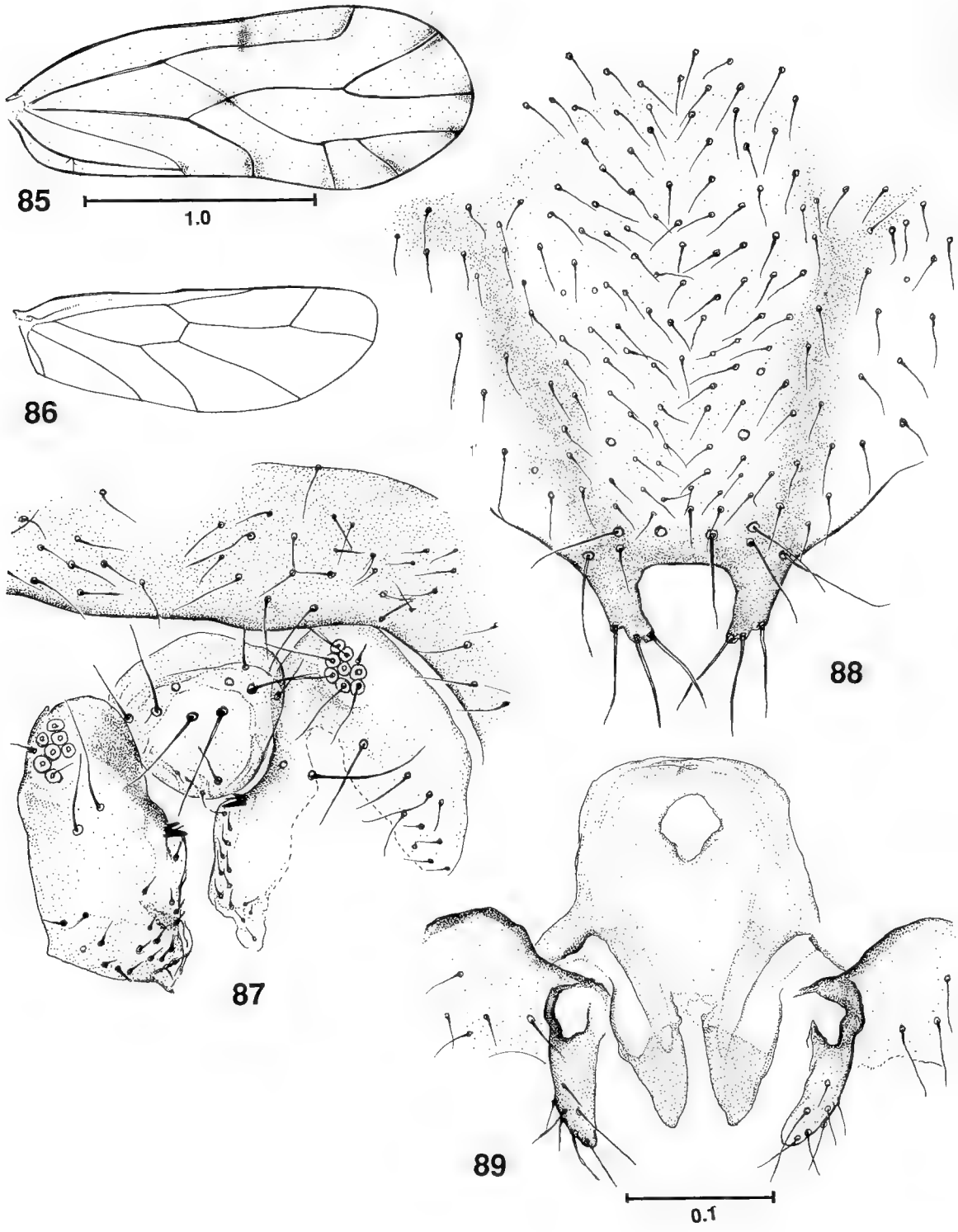
Remarks. This is the first record of this species since its description from near Sydney, NSW. Here it was collected only from tree ferns associated with closed forest and scrub.

Ectopsocus rileyae sp. nov.

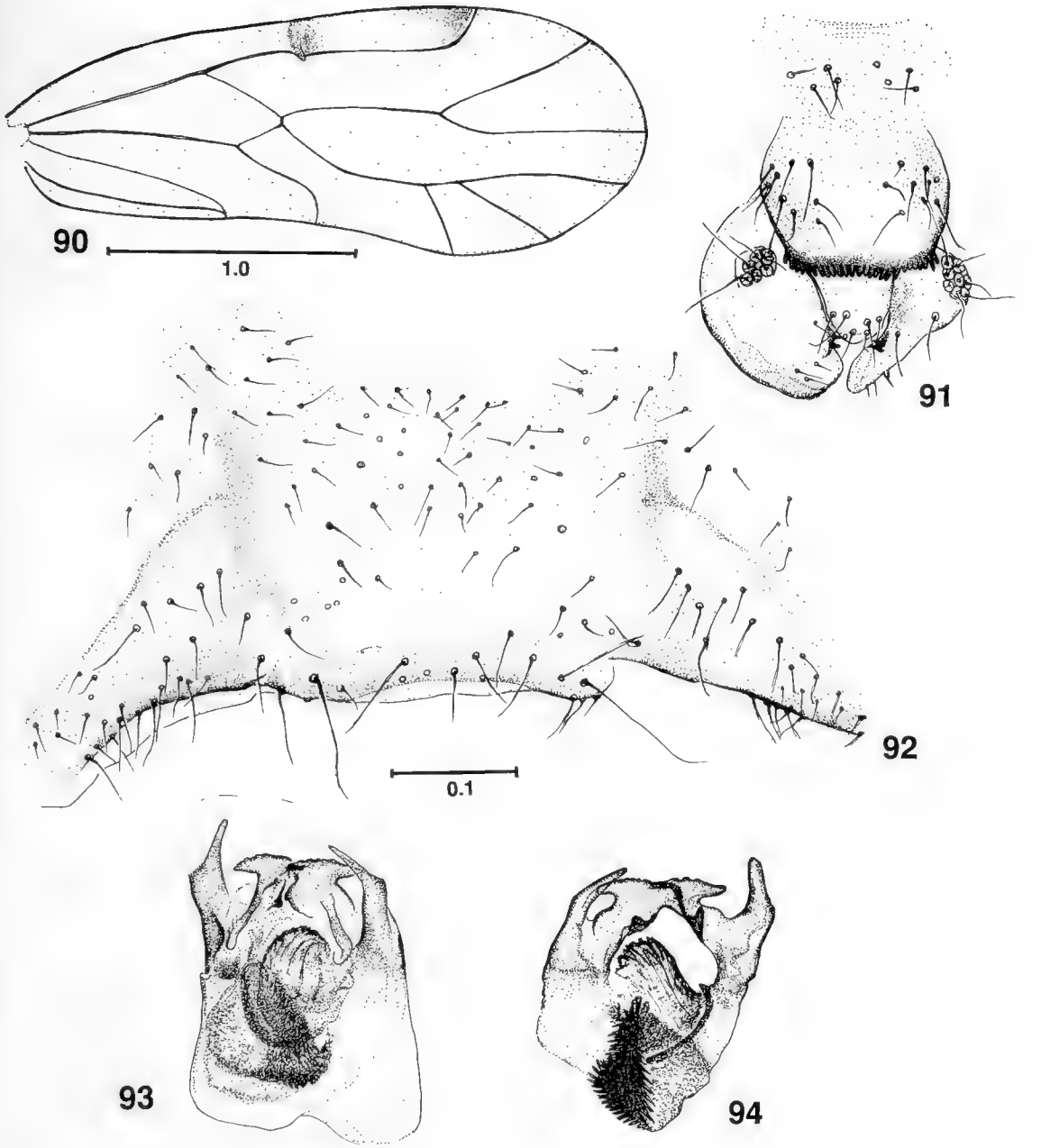
Figures 85–94

Material examined. Holotype ♀: Mt Maurice Walking Track, Tasmania, dead *Eucalyptus* leaves, 22 Feb 1988; allotype ♂, 2♀ and 1♂ paratypes: same data as holotype (K73645–K73649). Additional records (4♀): site 7 (Nov 1985, Jan 1986), site 19, site 28. Additional specimen before us: ♂, Tunbridge–Lake Sorrell Road, Tasmania, *Acacia melonoxylon*, 14 Aug 1986 (phallosome drawn).

Description of female. Coloration (after ca 3 yr in alcohol). Head generally buff with brown markings as follows: on vertex each side of median epicranial suture but leaving a buff stripe along midline; parallel to orbital margins again leaving pale buff band adjacent to orbit; ocellar protuberance, and a diagonal brown band anterolaterally from this to join a transverse band posterior to frons-clypeal suture, leaving pale triangular area (apex of triangle at anterior ocellus); striae over posterior half of postclypeus, leaving a pale narrow band medially; antenna; apical segment of maxillary palp; labrum. A dark brown band from orbit to antennal socket, ocelli with dark brown margins except anterior ocellus anteriorly. Eyes black.



Figures 85–89. *Ectopsocus rileyae*. Female: 85, forewing; 86, hindwing; 87, epiproct and paraprocts; 88, subgenital plate; 89, gonapophyses and spermathecal plate. Figures 85, 86 and 87–89 to common scales.



Figures 90–94. *Ectopsocus rileyae*. Male: 90, forewing; 91, epiproct, paraprocts and ninth tergite; 92, hypandrium; 93, phallosome; 94, phallosome (Tasmanian specimen). Figures 91–94 to common scale.

Gena, maxillary palp (except apical segment) and anterior half of postclypeus cream. Thoracic terga brown with buff margins adjacent to sutures, a broad brown band along side of cervicum and thorax. Legs, including coxae, very pale buff. Fore wing (fig. 85) membrane very pale brown, except hyaline in posterior marginal cells and costal cells; apices of veins extensively pigmented darker brown, *rs-m* junction with small brown cloud. Hind wing (fig. 86) hyaline. Abdomen with fairly broad grey-brown annulations.

Morphology. IO:D = 7.5. Epiproct (fig. 87).

Paraproct (fig. 87) with field of 7 trichobothria and a seta without rosette, duplex spines with associated seta as in *E. australis*. Subgenital plate (fig. 88) with subapical transverse row of 7 long setae on disc; apical lobes not separated from body of plate basally, short, broad, slightly curved towards midline, each with 3 apical setae, no projection between bases of inner pair of setae; plate with sclerotised band each side running into apical lobes and along posterior margin of plate. Gonapophyses (fig. 89): outer valve fairly straight, with 7 setae, valve small, little larger than dorsal valve (cf. *E. australis* above); dorsal valve subtriangular, apices finely spiculate; ventral valve broad compared to *E. australis*, inner margins spiculate. Spermathecal plate (fig. 89) lightly sclerotised with large unsclerotised area around gonopore.

Dimensions. B 2.1, FW 1.95, HW 1.55, F 0.49, T 0.75, t_1 0.213, t_2 0.087, rt 2.4:1, ct 12, 0, f_1 0.442, f_2 0.253.

Description of male. Coloration (after ca 3 yr in alcohol). As female with following exceptions: paler triangular area anterior to ocelli absent, posterior half of postclypeus darker brown, no median narrow stripe. Dark brown lateral stripe on thorax narrower, sclerites dorsal to this brown. Tibiae and tarsi slightly greyish. Dark pigment along apical sections of fore wing veins (fig. 90) much less obvious than in female.

Morphology. IO:D = 5.3. Epiproct (fig. 91) setose over apical third only. Paraproct (fig. 91) with field of 7 trichobothria and duplex spines separated almost to base, spines rather unequal in length. Ninth tergite (fig. 91) with prominent comb of single row of teeth. Eighth and ninth tergites without other ornamentation. Hypandrium (fig. 92) similar to *E. australis*. Phallosome (fig. 93): inner parameres fusing posteriorly into bicornate structure characteristic of this group of species but with crenulate posterior margin; at least 1 massive phallosome sclerite and 1 curved serrate sclerite; small conical projections half way along inner parameres [not seen on type preparation but illustrated (fig. 94) from another Tasmanian specimen].

Dimensions. B 1.7, FW 2.54, HW 1.98, F 0.50, T 0.85, t_1 0.253, t_2 0.091, rt 2.8:1, ct 15, 0, f_1 0.521, f_2 0.340.

Etymology. This species is named after Cathy Riley for her assistance during this project.

Remarks. Females of this species were collected from Wilsons Promontory, in tall open forest. Both sexes were found from Tasmania, thus these specimens were designated types.

Genitalic differences from other species in this group are tabulated in Table 3. *E. rileyae* is the only species of this group in which the male is known to lack ornamentation of the eighth tergite.

Peripsocidae Pearman

Peripsocus Hagen

Peripsocus Hagen, 1866: 203. Type species: *Psocus phaeopterus* Stephens.

Peripsocus bifasciatus sp. nov.

Figures 95–102

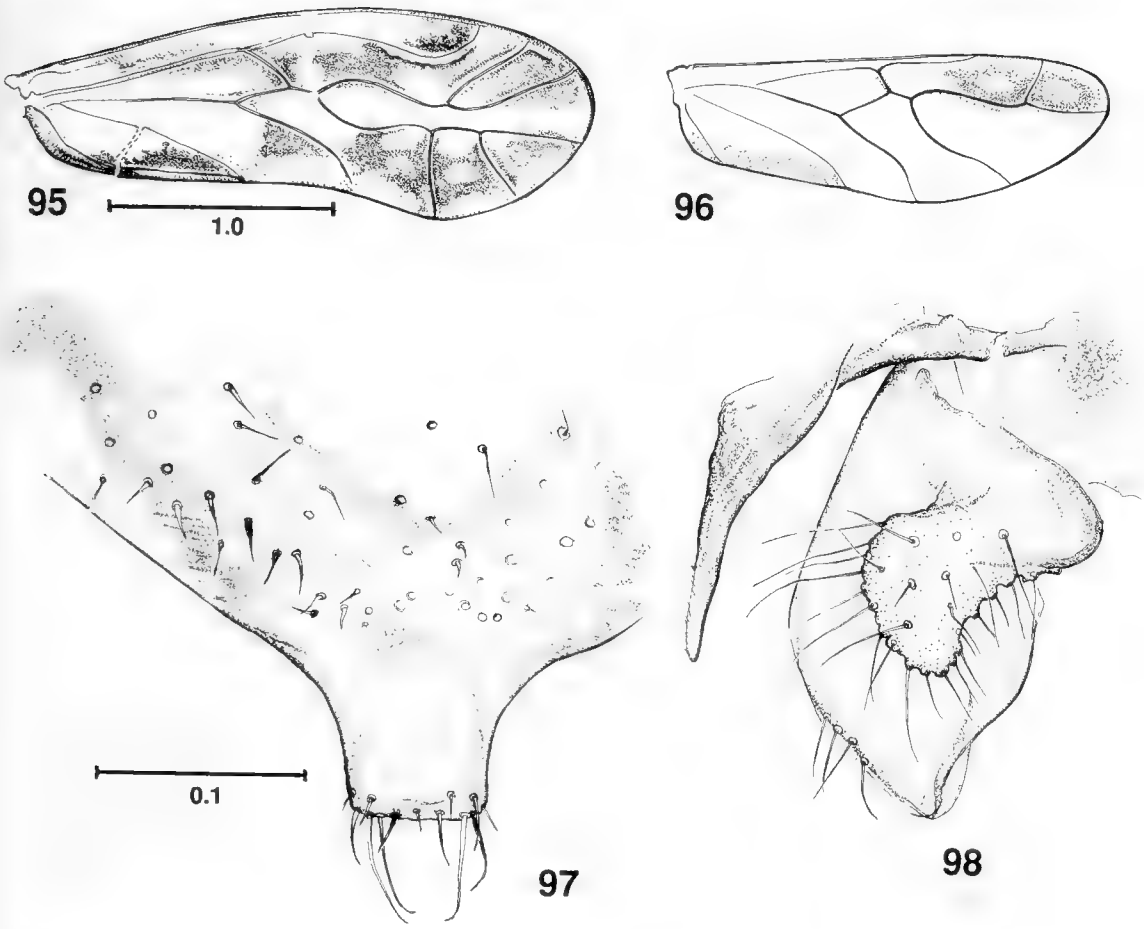
Material examined. Holotype ♀: Waterpump shed, *Melaleuca ericifolia*, 27–29 Mar 1985; allotype ♂: Lilly Pilly Nature Track, heath, 21–23 Apr 1985; 4 nymphs, 1♀ and 9♂ paratypes: same locality as holotype, 21–23 Feb 1986 (K73650–K73677). Additional records (32♀, 25♂, 10 nymphs): site 3 (May, Jun, Sep, Nov 1985, Jan 1986), site 4 (May, Jun, Aug, Sep, Oct, Nov, Dec 1985, Jan 1986), site 5 (Mar, Jun, Sep, Nov, Dec 1985, Jan 1986), site 8 (Sep, Oct 1985), site 9 (Nov, Dec 1985, Jan 1986), site 10 (Jan 1986), site 19, site 27, site 31, site 42.

Description of female. Coloration (after ca 5 yr in alcohol). Head generally buff, usual markings on vertex as brown spots. Eyes black. Antenna with scape, pedicel and f_1 pale buff, f_1 shading to light brown apically, rest of flagellum light brown. Ocellar protuberance with black rim, ocelli also with black surrounds. Immediately anterior to ocellar protuberance a brown spot slightly smaller than protuberance. Postclypeus with 6 regular V-shaped brown striae. Gena buff, unmarked. Anteclypeus buff, labrum dark brown. Maxillary palps pale buff, apical segment light brown apically. Dorsal lobes of thorax brown, bordered buff; mesothoracic antedorsum with median buff line separating brown pigment each side. Legs pale buff except coxa light brown, protibia brown in apical half, tarsal segments light brown. Fore wing patterned with brown pigment as in fig. 95, wing with 2 very irregular longitudinal brown bands. Hind wing with longitudinal brown band anteriorly (fig. 96).

Morphology. IO:D = 4.5. Epiproct broad, trapezoidal, setose. Paraproct with field of 19 trichobothria. Subgenital plate (fig. 97). Gonapophyses (fig. 98).

Dimensions. B 1.8, FW 2.48, HW 1.89, F 0.37, T 0.71, t_1 0.190, t_2 0.111, rt 1.7:1, ct 12, 0, f_1 0.324, f_2 0.245.

Description of male. Coloration (after ca 5 yr in alcohol). As female, except fore wing (fig. 99)



Figures 95–98. *Peripsocus bifasciatus*. Female: 95, forewing; 96, hindwing; 97, subgenital plate; 98, gonapophyses. Figures 95, 96 and 97 and 98 to common scales.

pattern less intense, no brown pigment along basal section of vein r_1, femur light brown.

Morphology. IO:D = 0.8. Hind wing (fig. 100). Epiproct (fig. 101). Paraproct (fig. 101) with field of 36 trichobothria. Ninth tergite (fig. 101) with projecting curved lobe bearing a row of pointed teeth, some smaller teeth anterior to this. Hypandrium (fig. 102) simple. Phallosome (fig. 102) with pair of tridentate sclerites and more apically a pair of rounded sclerites with pointed apices.

Dimensions. B 1.6, FW 2.71, HW 2.06, F 0.40, T 0.80, t_1 0.245, t_2 0.111, rt 2.2:1, ct 15, 0, f_1 0.419, f_2 0.352.

Remarks. This species is unique both in wing pattern and features of male and female genitalia. It was found predominantly in heathland and scrub, but also in open forest.

Peripsocus maoricus (Tillyard)

Peripsocopsis maoricus Tillyard, 1923: 194.
Peripsocus maoricus. — Roesler, 1944: 154.

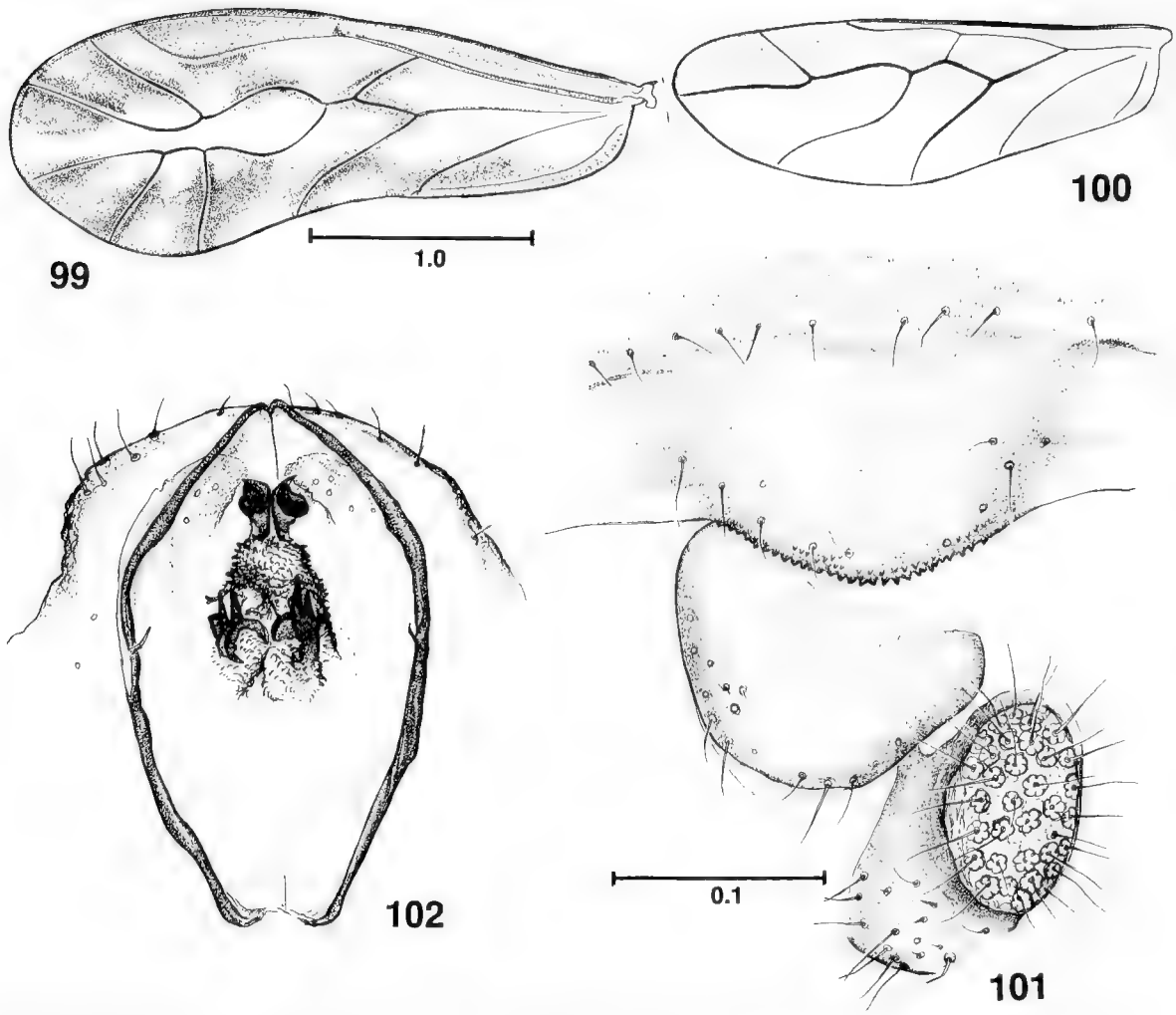
Material examined. 22♀, 12♂, 3 nymphs: site 3 (Feb 1986), site 9 (Mar, May, Jul, Sep, Oct, Dec 1985, Jan 1986), site 14 (Apr 1984), site 15 (Apr 1984), site 19, site 26, site 27, site 29, site 34, site 36, site 40.

Remarks. This species is widely distributed in southern Australia, and has been recorded previously from Wilsons Promontory. Found predominantly in low open forest (site 9) as well as heathland and *Melaleuca* scrub.

Peripsocus melaleucae New

Peripsocus melaleucae New, 1971: 224.

Material examined. 27♀, 5♂, 2 nymphs: site 9 (Jan 1986), site 14 (Apr 1984), site 20, site 36.



Figures 99–102. *Peripsocus bifasciatus*. Male: 99, forewing; 100, hindwing; 101, epiproct, paraproct and nith tergite; 102, phallosome and hypandrium. Figures 99, 100 and 101 and 102 to common scales.

Remarks. This species of heath and scrub has been recorded only from the Grampians, Victoria and the Bass Strait islands.

Peripsocus milleri (Tillyard)

Peripsocopsis milleri Tillyard, 1923: 195.
Peripsocus milleri. — Roesler, 1944: 154.

Material examined. 3♀, 2♂: site 7 (Feb 1986), site 8 (Jan 1991), site 14 (Apr 1984), site 19.

Remarks. P. milleri has previously been recorded from Wilsons Promontory. Its distribution is similar to that of *P. maoricus* but it is less common and has not yet been recorded from South Australia or the Bass Strait islands. In this survey it was found in tall open and closed forest.

Peripsocus tillyardi New

Figures 103–108

Peripsocus tillyardi New, 1973a: 343.

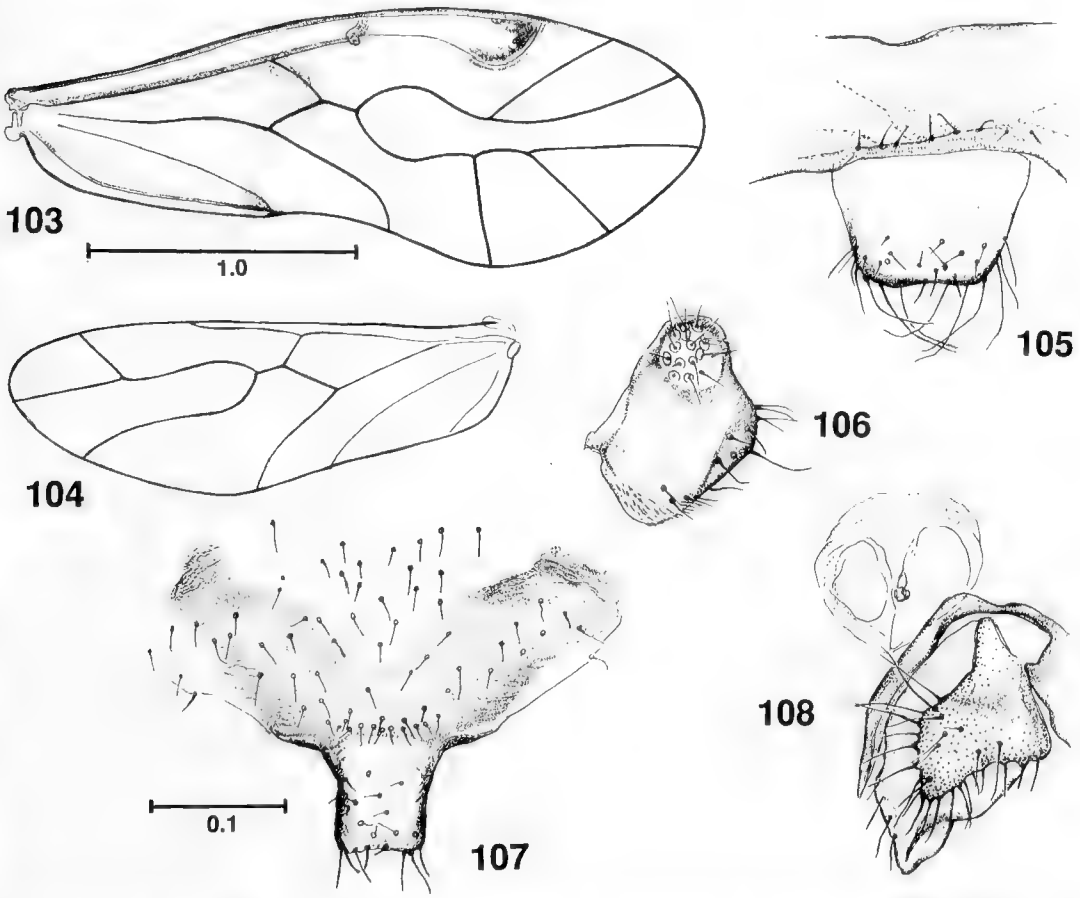
Material examined. Specimen on which description based: ♀, Lilly Pilly Nature Track 'The Loop', closed forest, 5–6 Jan 1986. Additional records (148♀, 74♂, 10 nymphs): site 2 (Feb 1986), site 3 (Feb, Mar, Nov, Dec 1985, Jan, Feb 1986), site 4 (Mar, Jun, Aug, Sep 1985, Jan, Feb 1986), site 5 (Apr, May, Jul, Sep, Dec 1985, Jan, Feb 1986), site 7 (May 1985), site 8 (Feb, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan 1986), site 9 (May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986, Jan 1991), site 10 (May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 12, site 13, site 14 (Apr 1984, Apr 1990), site 19, site 21, site 22, site 24, site 25, site 26, site 27, site 28 (Apr 1990), site 29, site 31, site 32, site 37, site 39, site 42.

Description of female. Coloration (after ca 5 yr in alcohol). As male with following exceptions: vertex with areas of confluent brown patches along posterior margin, flanking epicranial suture, and mesad of orbits, leaving pale buff areas as follows each side: 1 just posterior to orbit, 2 in line parallel to epicranial suture, and 1 elongate area anterior to orbit. Maxillary palp with 2 apical segments very dark brown, remainder very pale buff. Fore wing pattern (fig. 103). Legs with coxa brown; basal third of femur pale buff, mid third brown, apical third pale buff; basal two-thirds of tibia pale greyish brown, apical third brown; tarsal segments brown. Abdomen dark greyish brown.

Morphology. IO:D = 2.8. Hind wing (fig. 104). Epiproct (fig. 105) squarish. Paraproct (fig. 106) with raised circular field of 14-16 trichobothria. Subgenital plate (fig. 107). Gonapophyses (fig. 108).

Dimensions. B 1.8, FW 2.54, HW 1.86, F 0.37, T 0.77, t_1 0.158, t_2 0.059, rt 2.7:1, ct 16, 0, f_1 0.245, f_2 0.186.

Remarks. We provide a description of the female of this species, hitherto known only from the male. On re-examining the male holotype the femur was seen to be pale over the basal quarter, shading to brown over the middle half and abruptly changing to pale over the apical quarter; the tibia is pale in the basal half shading to brown in the apical half. Also known from the Grampians, NSW, Bass Strait islands and the Melbourne area, the species was found at Wilsons Promontory in almost all habitats sampled; it was not found in the *Banksia* or mangrove habitats.



Figures 103–108. *Peripsocus tillyardi*. Female: 103, forewing; 104, hindwing; 105, epiproct; 106, paraproct; 107, subgenital plate; 108, gonapophyses. Figures 103, 104 and 105–108 to common scales.

Pseudocaeciliidae Pearman

Austropsocus Smithers

Austropsocus Smithers, 1962: 930. Type species: *Austropsocus insularis* Smithers.

Austropsocus antennalis Thornton and New

Austropsocus antennalis Thornton and New, 1977: 24.

Material examined. 2♀, 6♂, 1 nymph: site 6 (Apr, May 1985), site 7 (Mar, May, Dec 1985), site 28 (Apr 1991 – off nearby dead *Eucalyptus* leaves).

Remarks. This species has previously been recorded from north Queensland, NSW and the Bass Strait islands. At Wilsons Promontory it was taken in bracken and in tall open forest.

Austropsocus cornutus sp. nov.

Figures 109–118

Material examined. Holotype ♂: Millers Landing, *Avicennia marina*, 17 Apr 1990; allotype ♀, 4 nymphs, 4♀, 4♂ paratypes: same data as holotype (K73678–K73687). Additional records (11♀, 6♂, 9 nymphs): site 28 (Apr 1991), site 33.

Description of female. Coloration (after ca 6 mo in alcohol). Body generally buff. Head pattern (fig. 109): adjacent brown spots dorsal to orbits across posterior of vertex and flanking medial epicranial suture, which is dark brown. Ocellar protuberance dark grey, ocelli pale with centripetal black margins, protuberance surrounded by granulated grey area which is broader anteriorly than posteriorly and in middle of frons takes the form of a heart shaped brown spot with granulated grey margins, the size of ocellar protuberance. Postclypeus with obvious striae converging anteriorly in V patterns, anteclypeus and labrum dark brown. Gena with a few dark spots below eye. Maxillary palp apical segment brown apically. Antenna: scape brown, pedicel pale brown, f_1 and f_2 pale buff, f_3 brown, f_4, f_5, f_6 dark brown, remainder of flagellum brown. Eyes black. Setae of head dark brown. Thorax with dark brown dorsal lobes, intermediate areas buff, pleura predominently brown. Legs pale, t_1 light brown, t_2, t_3 darker grey-brown. Fore wing (fig. 110) with brown pigment along veins. Hind wing (fig. 111) hyaline. Abdomen cream with broad grey-brown annulations.

Morphology. IO:D = 5.0. Antennae with long, stiff setae. Fore wing short compared to that of male. Vein setae in 2 ranks apically, basally in 3 ranks and of 2 lengths, some at least twice as long as others. Claw without subapical tooth. Epiproct (fig. 112) with prominent pattern of 7 long stiff setae, and shorter more slender setae, an extremely stout seta on a slightly raised area subapically. Paraproct (fig. 112) with round field of 12 trichobothria. Subgenital plate (fig. 113) bilobed, each lobe with row of 3 stout setae, apical margin with minute spicules; at base of apical sclerotised lobes a row of 3 and 4 long setae, more anteriorly 4 well-spaced extremely long setae. Gonapophyses (fig. 114): ventral valve spiculate, narrow, bluntly ended, evenly tapering; dorsal valve with subapical lobe extending almost to apex of spiculate apical tine; outer valve ovoid with scattered, very long setae.

Dimensions. B 3.0, FW 2.24, HW 1.80, F 0.63, T 0.94, t_1 0.221, t_2 0.071, t_3 0.071, rt 3.1:1:1, ct 0, 0, 0, f_1 0.474, f_2 0.261.

Description of male. Coloration (after ca 6 mo in alcohol). As female with following exceptions: vertex without distinct pattern of brown patches, rather a brown uniform ground color where these patches occur in female; brown spots on gena below eye absent. Antennal colour: scape brown, pedicel and f_1 buff, f_2 light brown, rest of flagellum brown. Fore wing without brown pigment along veins (fig. 115).

Morphology. IO:D = 2.3. Fore wing longer than female, veins narrower. Hind wing as fig. 116. Epiproct trianguloid, setose. Paraproct with oval field of 17 trichobothria. Hypandrium structure (fig. 117) similar to that of *Austropsocus omega* Thornton and New, 1977, differing, however, in that median apical lobe is prolonged laterally into a sclerotised curved pointed tine. Phallosome penial bulb sclerites (fig. 118) as those of *A. omega*, and in addition a basal pair of narrow curved sclerites.

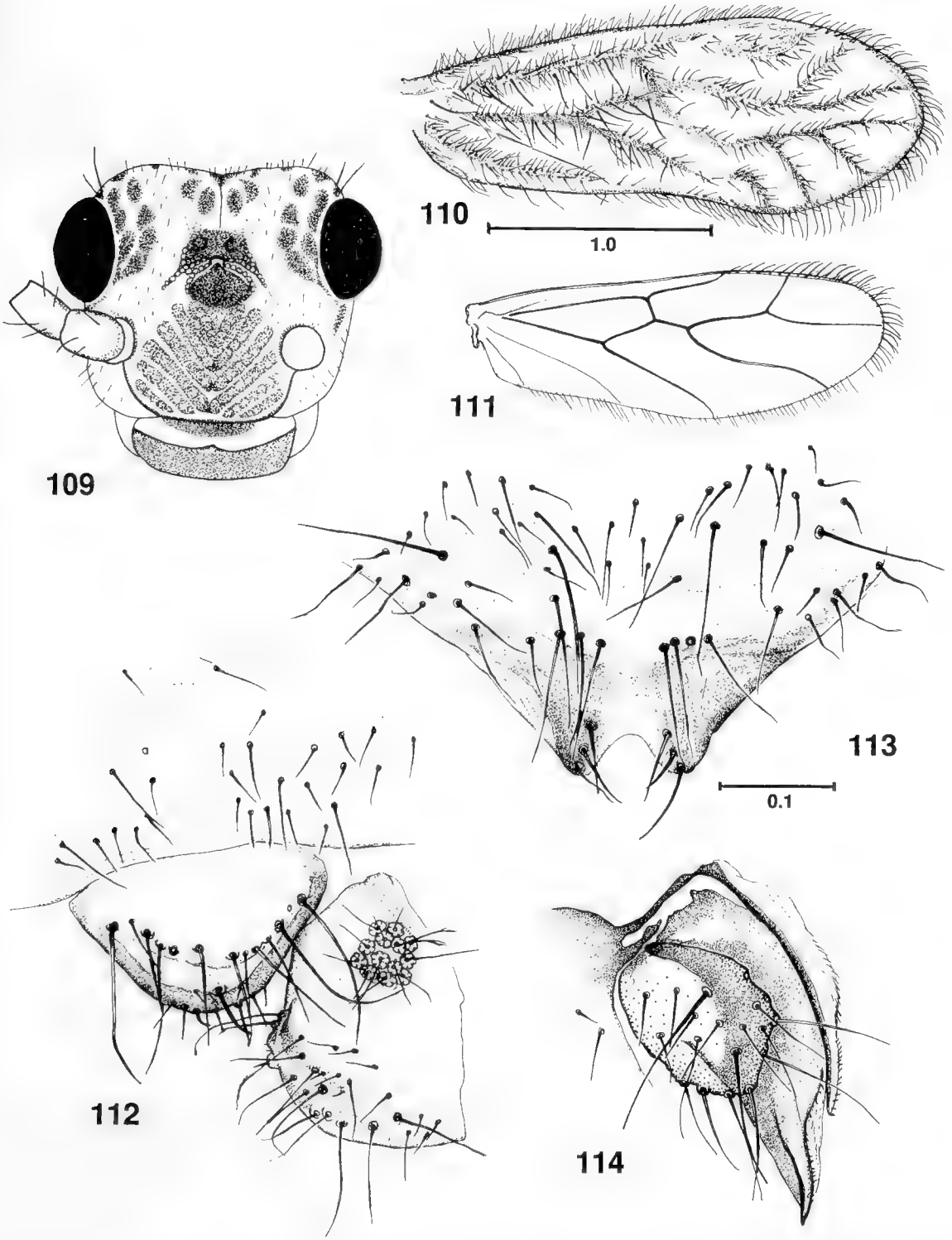
Dimensions. B 2.6, FW 3.51, HW 2.79, F 0.69, T 1.11, t_1 0.237, t_2 0.071, t_3 0.079, rt 3.3:1:1.1, ct 10, 0, 0, f_1 0.826, f_2 0.547.

Remarks. Austropsocus cornutus, found in mangroves and closed forest, keys to couplet 9 in the key of Thornton and New (1977). In the fore wing vein *rs* is only slightly curved and bears setae in 3 ranks. This sexually dimorphic species may be distinguished on head pattern and features of male genitalia; the lateral horn-shaped prolongations of the median lobe of the hypandrium are unique.

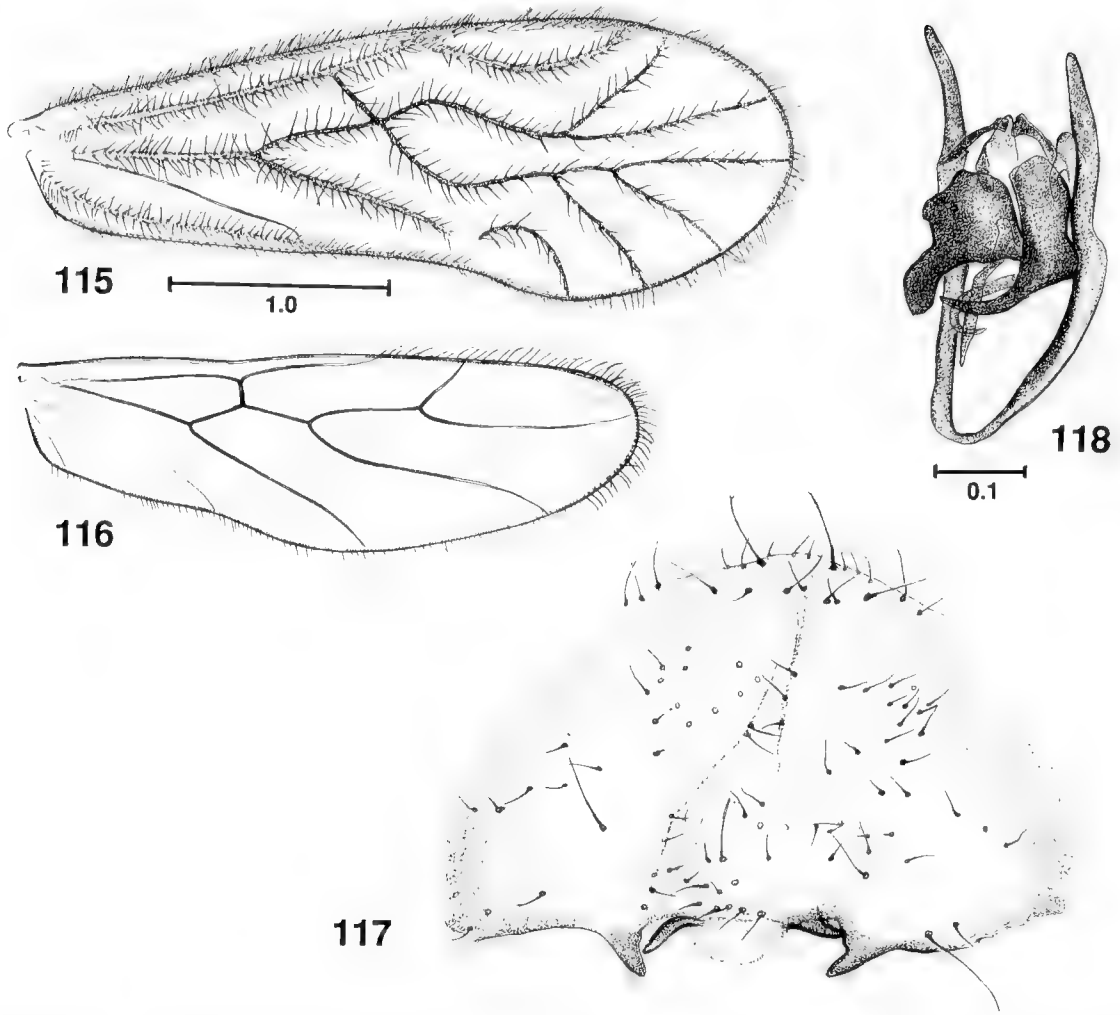
Austropsocus costalis Thornton and New

Figures 119–122

Austropsocus costalis Thornton and New, 1977: 36.



Figures 109–114. *Austropsocus cornutus*. Female: 109, head pattern; 110, forewing; 111, hindwing; 112, epiproct and paraproct; 113, subgenital plate; 114 gonapophyses. Figure 109 not to scale. Figures 110, 111 and 112–114 to common scales.



Figures 115–118. *Austropsocus cornutus*. Male: 115, forewing; 116, hindwing; 117, hypandrium; 118, phallosome. Figures 115, 116 and 117 and 118 to common scales.

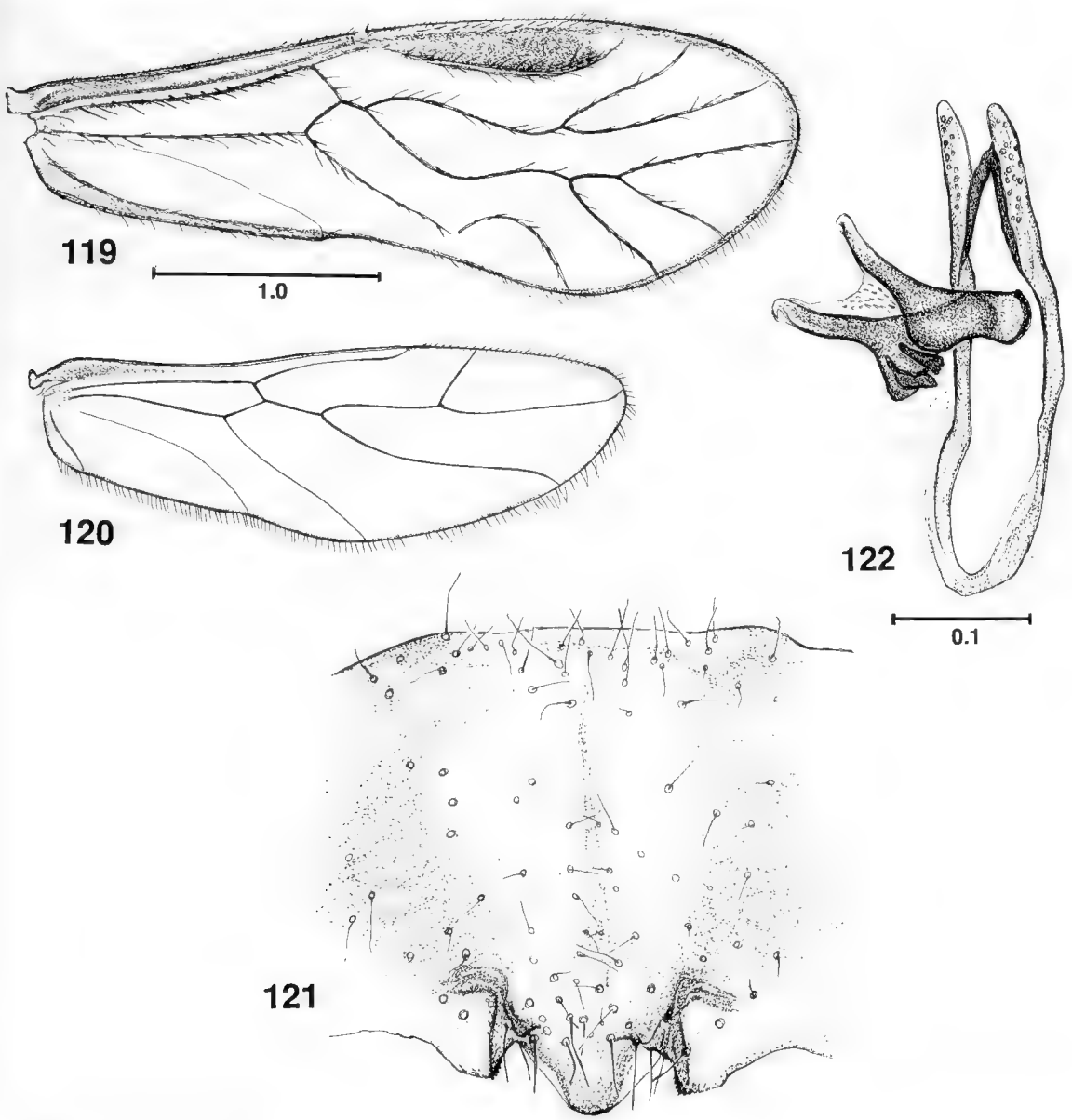
Material examined. Specimen on which description based: ♂, Lilly Pilly Nature Track, low open forest, 11–13 Aug 1985. Specimen on which dimensions of ♀ based: ♀, locality as ♂, 8–10 Sep 1985. Additional records (5♀, 4♂): site 2 (Sep, Oct 1985, Jan 1986), site 9 (Nov 1985, Jan 1986), site 44.

Description of male. Coloration (after ca 5 yr in alcohol). As female, with following exceptions: maxillary palps dark brown, basal flagellar segment slightly paler than more apical segments, except towards distal end.

Morphology. IO:D = 2.1. Generally as female, with following exceptions: length of flagellar setae > 3 times width of basal flagellar segment. Epiproct rounded trianguloid with sparse short setae and 2 longer setae at margin on each side. Paraproct with oval field of 20 trichobothria and 2 setae within field not with rosette sockets. Fore wing as fig. 119; hind wing as fig. 120. Hypandrium (fig. 121) 5-lobed, the pair of lobes adjacent to the central lobe very small and sclerotised, outer pair of lobes of characteristic shape and finely serrate. Phallosome (fig. 122) with pair of large distinctively-shaped sclerites, and pair of small wedge-shaped pointed sclerites.

Dimensions. B 1.9, FW 3.45, HW 2.65, F 0.52, T 1.08, t_1 0.392, t_2 0.071, t_3 0.079, rt 5.5:1:1.1, ct 21, 0, 0, f_1 0.64, f_2 0.379.

Further description of female. Dimensions (see remarks below). F 0.46, T 0.91, t_1 0.292, t_2 0.071, t_3 0.071, rt 4.1:1:1, ct 15, 0, 0, 0, f_1 0.450, f_2 0.276.



Figures 119–122. *Austropsocus costalis*. Male: 119, forewing; 120, hindwing; 121, hypandrium; 122, phallosome. Figures 119, 120 and 121 and 122 to common scales.

Remarks. We provide a description of the male of this species, previously known only from the female. In this survey *A. costalis* was found in low open forest (site 9) and eucalypt woodland (site 2), as well as coastal vegetation.

Described from a single Queensland female found high on the Atherton Tablelands, the discovery of both sexes of this species at the southern extremity of continental Australia (and on the Bass Strait islands) is of interest. Examination of the Wilsons Promontory specimens shows that the connection between *rs* and *m* of the fore wing is variable. The type female lacked antennae and hind legs; we therefore provide dimensions of these body parts from one of our females.

Thornton and New (1977) separated *costalis*, along with six other Australian species having only two setae on the subgenital plate and a 2- or 4-lobed hypandrium, from a group of four Aus-

tralian species having five or more apical setae on the female subgenital plate and a 5-lobed hypandrium. Our discovery of the male and examination of its genitalia shows that *costalis* does not fall into either of these two groups. Its female subgenital plate has but two apical setae and the hypandrium is 5-lobed. In hypandrial structure and phallosome sclerites it is most similar to *Austropsocus baeus* Thornton and Smithers from New Caledonia, of which the female is unknown, and, like the other New Caledonian species in which the male is known, the phallosome lacks the pair of spinous sacs present in some New Zealand species. The five New Caledonian species of which the female is known have a very long subapical spine on the dorsal valve of the gonapophyses, and in this feature they differ from females of all Australian and New Zealand species of the genus, except *Austropsocus hyalinus* Thornton, Wong and Smithers and *A. costalis*. Significantly, the range of both these species extends to north Queensland.

Austropsocus hyalinus
Thornton, Wong and Smithers

Austropsocus hyalinus Thornton, Wong and Smithers, 1977: 219.

Material examined. 37♀, 14 nymphs: site 7 (Jan 1986), site 8 (Mar, Apr, May, Aug, Sep, Oct, Dec 1985, Jan 1986, Jan 1991), site 28 (Apr 1990), site 38, site 39.

Remarks. This species of closed forest (site 8), previously recorded from north Queensland, NSW, Victoria and the Bass Strait islands, was originally described from New Zealand. Only females have been collected from Wilsons Promontory.

Austropsocus sinuosus (Banks)

Zelandopsocus sinuosus Banks, 1939: 441.
Austropsocus sinuosus. — Thornton and New, 1977: 28.

Material examined. 2♀: site 7 (Apr 1985), site 19.

Remarks. A widespread species found in all eastern mainland states, Tasmania, the Bass Strait islands and South Australia. Found only in one habitat in this survey: tall open forest.

Austropsocus tibialis Thornton and New

Austropsocus tibialis Thornton and New, 1977: 30.

Material examined. 14♀, 2♂: site 28 (Apr 1990, Apr 1991), site 38.

Remarks. A common species recorded from eastern Australian from the Bass Strait islands to north Queensland, it was found here at two sampling sites of closed forest.

Austropsocus viridis (Enderlein)

Philotarsus viridis Enderlein, 1903: 309.
Austropsocus viridis. — Thornton and New, 1977: 32.

Material examined. 104♀, 12♂, 35 nymphs: site 8 (Nov, Dec 1985, Jan 1986), site 11 (Apr 1984, Mar, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 25, site 28 (Apr 1990, Apr 1991), site 38, site 43.

Remarks. A. viridis has been collected from Victoria to north Queensland in eastern Australia. In this survey it was found predominantly on *Banksia serrata* (site 11) and in closed forest (site 8).

Cladioneura Enderlein

Cladioneura Enderlein, 1906: 404. Type species: *Cladioneura pulchripennis* Enderlein.

Cladioneura pulchripennis Enderlein
Cladioneura pulchripennis Enderlein, 1906: 405.

Material examined. 19♀, 19♂, 9 nymphs: site 2 (Nov 1985), site 3 (May 1985, Jan 1986 – nymph only), site 4 (Sep, Nov 1985, Jan 1986 – nymphs only), site 5 (Apr, Jul, Sep, Oct, Nov 1985, Jan 1986), site 6 (May, Jun 1985), site 8 (Sep, Oct, Nov 1985, Feb 1986), site 9 (Apr, Jul, Aug, Sep, Oct, Dec 1985, Jan, Feb 1986), site 10 (Aug 1985), site 27 (nymphs only), site 38, site 44.

Remarks. This species is known from NSW, Victoria, and the Bass Strait islands. It was collected in a variety of scrub and heathland sampling sites, as well as closed and low open forest.

Collective group "Heterocaecilius"
Lee and Thornton

Heterocaecilius Lee and Thornton, 1967: 13. No type species designated.

Remarks. Because no type species has ever been designated for this name it has no status as a genus (ICZN Article 42 (b) i). It is therefore to be treated as a "collective group", erected as a holding group to contain species of the family unassignable to any of the nominate genera.

"Heterocaecilius" brunellus (Tillyard)

Caecilius brunellus Tillyard, 1923: 188.
Pseudocaecilius brunellus. — Lee and Thornton, 1967: 111.
Heterocaecilius brunellus. — New, 1974a: 69.

Material examined. 43♀, 23♂, 16 nymphs: site 3 (Mar, Nov, Dec 1985, Jan, Feb 1986), site 4 (Jan, Sep, Oct 1985, Jan, Feb 1986 – nymph only), site 5 (Jan, Mar,

Apr, May, Jun, Sep, Oct, Nov, Dec 1985, Jan 1986), site 7 (Jan 1985), site 9 (Mar, May 1985, Jan, Feb 1986 – nymph only), site 14 (Apr 1984, Apr 1990, Jan 1991), site 17 (Jan 1985), site 18, site 20, site 25, site 26, site 29, site 30, site 38, site 42.

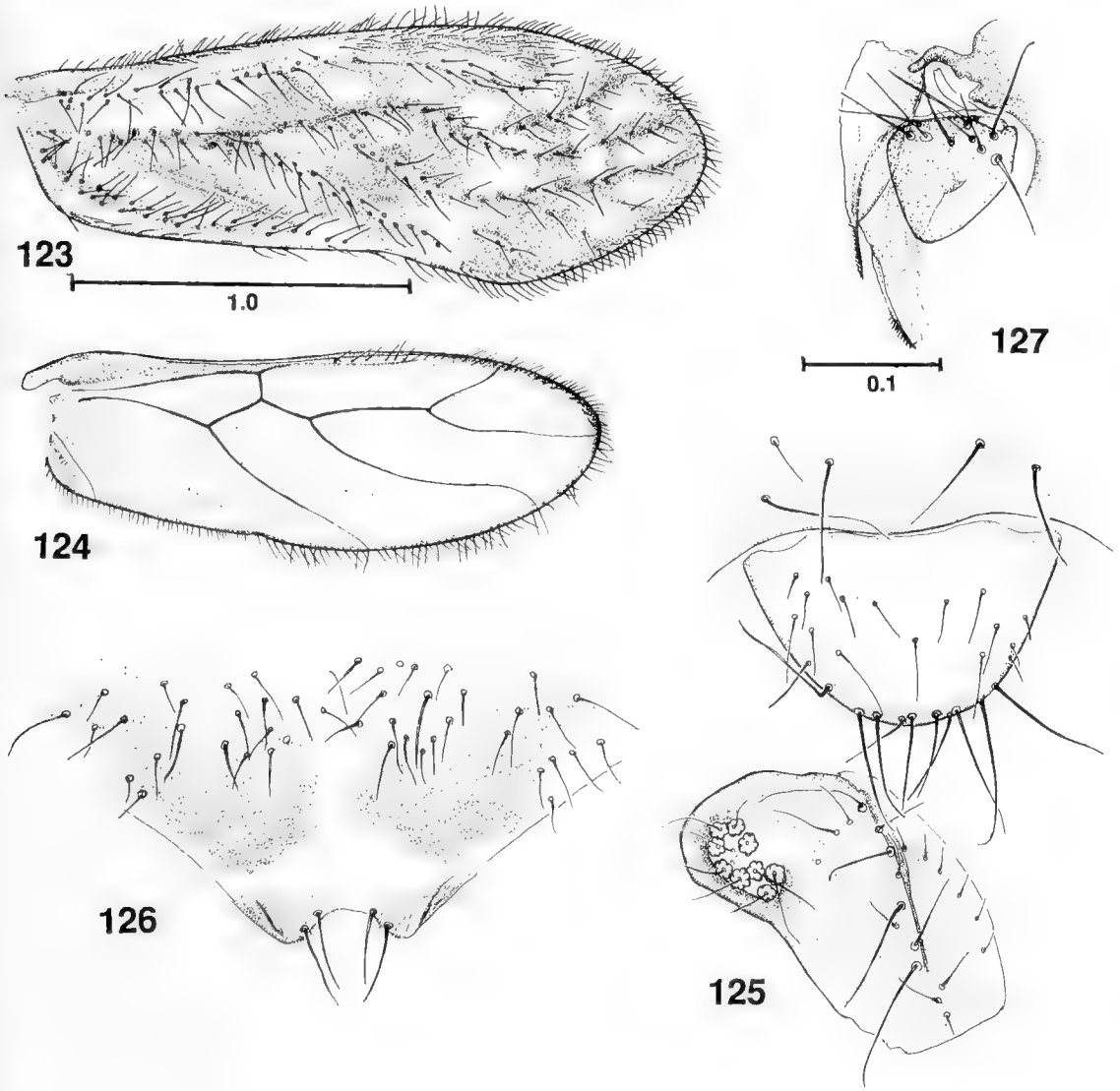
Remarks. This species, originally described from New Zealand, has been recorded from Tasmania, the Bass Strait islands, Victoria and NSW. At Wilsons Promontory it appears to be a species of heath and scrub vegetation, but also occurs in closed (site 8) and open (sites 7 and 9) forest.

"Heterocaecilius" lachlani (Enderlein)

Figures 123–132

Pseudocaecilius lachlani Enderlein, 1903: 263.

Material examined. Specimens on which descriptions based: ♀, Telegraph Saddle, low eucalypt woodland, 27–29 Mar 1985; ♂, Millers Landing Track, *Banksia serrata*, 21–23 Feb 1986. Additional records (11♀, 13♂, 8 nymphs): site 2 (Apr, Nov 1985, Jan, Feb 1986), site 4 (Sep, Oct 1985), site 5 (Apr 1985), site 9 (Nov 1985), site 11 (Feb 1986), site 13, site 14 (Apr 1984, Apr 1990), site 15 (Jan 1985), site 18.



Figures 123–127. *Heterocaecilius lachlani*. Female: 123, forewing; 124, hindwing; 125, epiproct and paraproct; 126, subgenital plate; 127, gonapophyses. Figures 123, 124 and 125–127 to common scales.

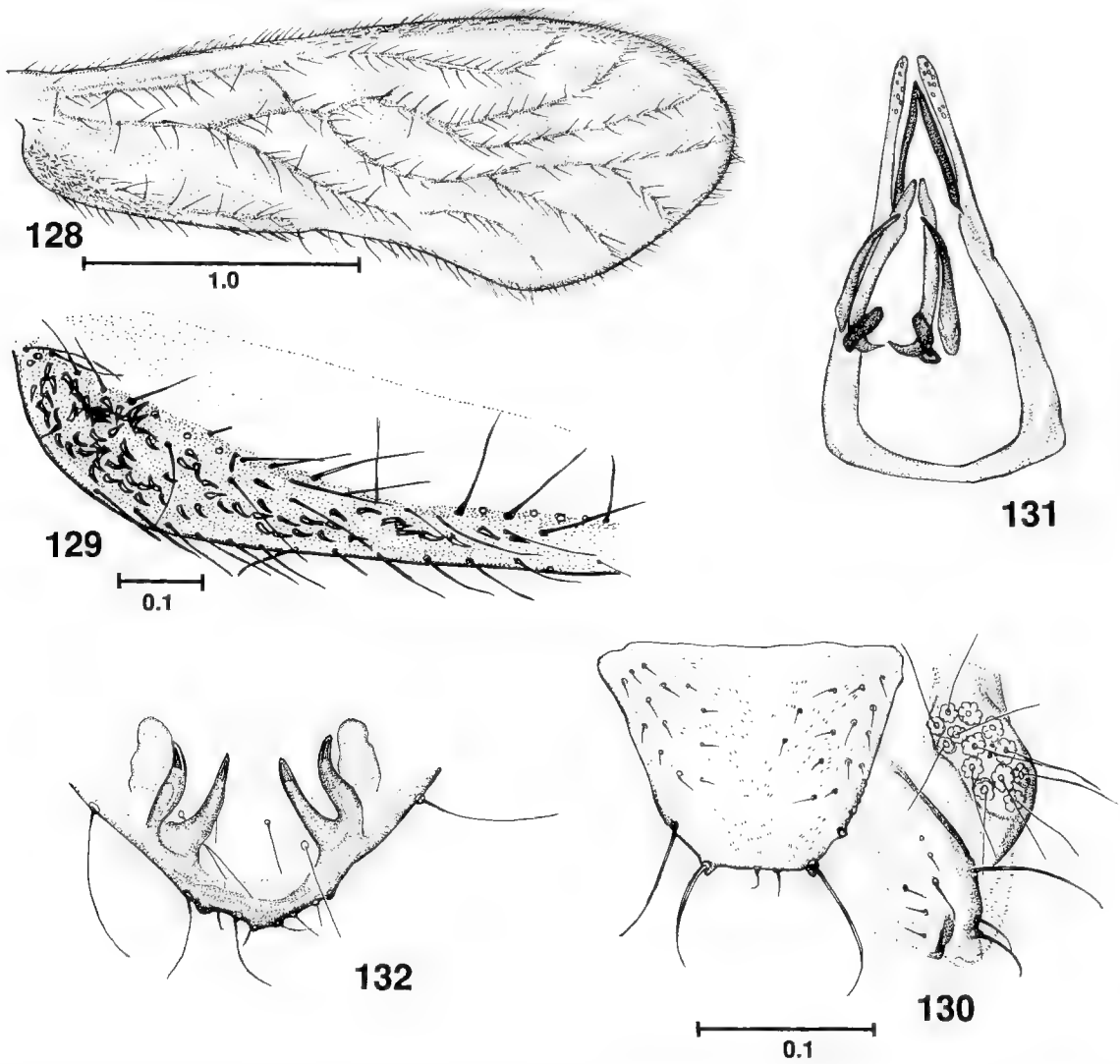
Description of female. Coloration (after ca 5 yr in alcohol). As Enderlein's description of male with following exceptions: head with distinct pattern, ground color pale buff, dark brown markings beside black epicranial suture and around orbits, postclypeus brown. Antenna light brown.

Morphology. IO:D = 6.0. Fore wing, fig. 123; hing wing fig. 124. Epiproct (fig. 125) simple, semi-circular, sclerotised near posterior margin, setose, setae on sclerotised portion longer than rest. Paraproct (fig. 125) with oval field of 9(10) trichobothria, and 1(2) setae not in rosette socket. Subgenital plate, fig. 126. Gonapophyses (fig. 127): both dorsal and ventral valves with distinct style and lobe, lobe of dorsal valve almost reaching apex of style.

Dimensions. B 1.6, FW 2.02, HW 1.62, F 0.46, T 0.85, t_1 0.261, t_2 0.107, rt 2.4:1, ct 13, 0, f_1 = 0.292, f_2 = 0.167.

Further description of male. Coloration (after ca 5 yr in alcohol). Much lighter than as described by Enderlein, body and wings lighter than female.

Morphology. IO:D = 1.5. Fore wing (fig. 128) longer than in female, a field of sensory (?) short curved sharply pointed papillae in anal cell (fig.



Figures 128–132. *Heterocaecilius lachlani*. Male: 128, forewing; 129, enlargement of anal cell of forewing; 130, epiproct and paraproct; 131, phallosome; 132, hypandrium. Figures 130–132 to common scale.

129). Epiproct (fig. 130) angular, hexagonal, outer edge sclerotised, straight posteriorly; at each of the 4 posterior angles a long stout seta, at least 4 times as long and thick as setae on surface of plate; a pair of short setae in middle of posterior margin; a field of pairs of small spicules adjacent to posterior margin. Paraproct (fig. 130) with field of 12(13) trichobothria and 1 seta not in rosette. Phallosome (fig. 131) with 3 pairs of rod-like radular sclerites, the longest stout, straight and bluntly pointed, 1 pair curved, narrower, slightly shorter and sharply pointed, and 1 pair very short, apparently twisted. Hypandrium (fig. 132) with 2 pairs of smoothly curved narrow projections with 'finger-nail' sclerites; a pair of smoothly rounded lobes laterally each side.

Dimensions. B 1.4, FW 2.57, HW 2.00, F 0.47, T 0.90, t_1 0.296, t_2 0.111, rt 2.7:1, ct 14, 0, f_1 0.446, f_2 0.30.

Remarks. Found in low eucalpyt woodland, scrub, and *Banksia*. Enderlein described only the male of this dimorphic species without reference to the genitalia. Smithers (1977) recorded both sexes at Muogamarra without further comment. We have dissected both sexes and provide a further description from specimens taken at Wilsons Promontory.

On characteristics of both male and female genitalia this species should not be placed in *Pseudocaecilius* Enderlein. Like another Australian species, *Caecilius brunellus* Tillyard, the hypandrium has pairs of posterior sclerotised 'finger-nail' projections, the phallosome has rod-like sclerites and the subgenital plate is bilobed, with each lobe being subtriangular bearing a subapical and mesial basal seta. The presence of radular sclerites and the form of the subgenital plate suggest placement of this species in Lee and Thornton's collective group, rather than in *Lobocaecilius* Lee and Thornton. However, like *C. brunellus*, it resembles *Lobocaecilius* species in the 'finger-nail' sclerites of the hypandrium, the field of tubercles on the male epiproct and papillae of the male fore wing. Lee and Thornton (1967) suggested that *C. brunellus* (under the name *diogenes*) was intermediate between *Lobocaecilius* and the *greenwoodi* section of "Heterocaecilius". On balance, *P. lachlani* is more similar to these than to other genera and is therefore part of this group.

Pseudoscottiella Badonnel

Pseudoscottiella Badonnel, 1946: 170. Type species: *Pseudoscottiella megops* Badonnel.

Pseudoscottiella papillosa sp. nov.

Figures 133–137

Material examined. Holotype ♀ : Lilly Pilly Nature Track, tall open forest, 15–16 Dec 1985 (K73688).

Description of female. Coloration (after ca 5 yr in alcohol). Body whitish-cream with the following exceptions: eyes black, thoracic nota pale brown, claws brown. Fore wing (fig. 133) hyaline, veins pale. Hind wing (fig. 134) hyaline.

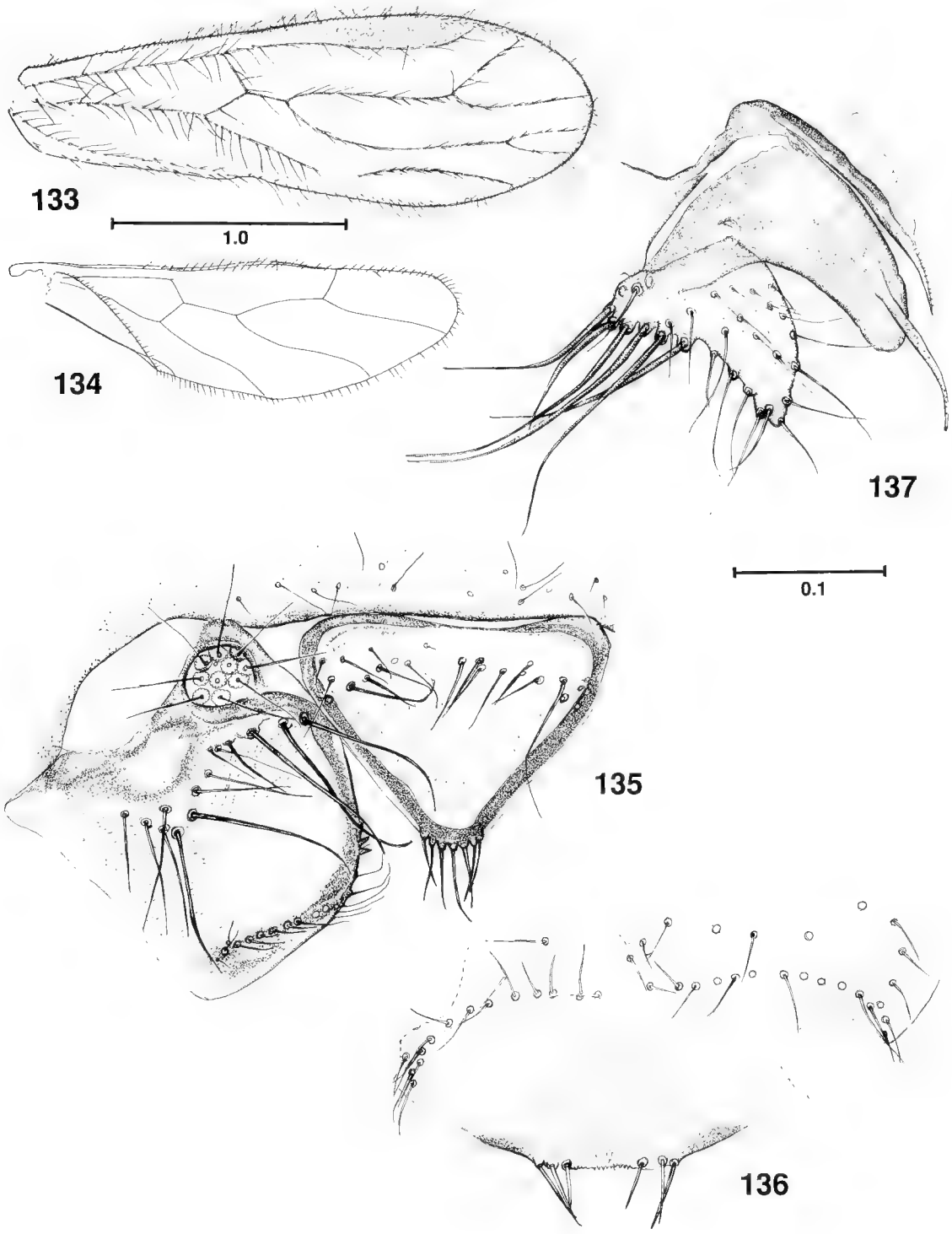
Morphology. IO:D = 6.0. Ocelli not obvious. Claw sharply recurved, without tooth. Epiproct (fig. 135) trianguloid, lateral and posterior edges thickened, highly sclerotised, with apical row of 7 setae, middle seta one-third longer than others, and a sub-basal transverse tract of setae, 1 very long seta at each end of this tract. Paraproct (fig. 135) with mesial border thickened, trichobothrial field circular with 10 trichobothria; mesial margin with a double cone and a small seta adjacent to this anteriorly, posterior to cone a long curved row of setae. Subgenital plate (fig. 136): 3 stout setae at each posterior angle, between these a field of fine spicules extending in midline anteriorly less than half width of field. Gonapophyses (fig. 137): external valve with row of 4–6 very long stout setae on raised papillae near base of valve, face of valve setose; dorsal valve with very long finely and sparsely papillose apical spine, subapical lobe extending half way along spine; spine of ventral valve with sparse recurved setules.

Dimensions. B 1.9, FW 2.39, HW 1.71, F 0.50, T 0.77, t_1 0.538, t_1 0.230, rt 2.3:1, ct 10, 0, f_1 0.261, f_2 0.186.

Male. Unknown.

Remarks. One of us (ERS) has taken a female of this species from the high tablelands of north Queensland. We have treated and stained the head capsule of this specimen, confirming the presence of ocelli.

Pseudoscottiella watti Smithers from the Kermadec Islands, which is very close to *P. papillosa* in colour of body, wings and venation (presence of ocelli not mentioned), is the only other species in which the outer valve of the female gonapophyses carries a row of very long setae sited on raised papillae. *P. papillosa* differs from *P. watti*, however, in the arrangement and size of setae near to the trichobothrial field of the paraproct, the shape and extent of the median field of spicules on the subgenital plate, and the chaetotaxy of the basal half of the epiproct.



Figures 133–137. *Pseudoscottiella papillosa*. Female: 133, forewing; 134, hindwing; 135, epiproct and paraproct; 136, subgenital plate; 137, gonapophyses. Figures 133, 134 and 135–137 to common scales.

Pseudoscottiella rotundata New

Figures 138–141

Pseudoscottiella rotundata New, 1974a: 67.

Material examined. Specimen on which description based: ♂, Lilly Pilly Nature Track, low open forest, 1–3 Nov 1985. Additional records (1♀, 6♂, 2 nymphs): site 17 (Jan 1985), site 19, site 25, site 28 (Apr 1990), site 38, site 39.

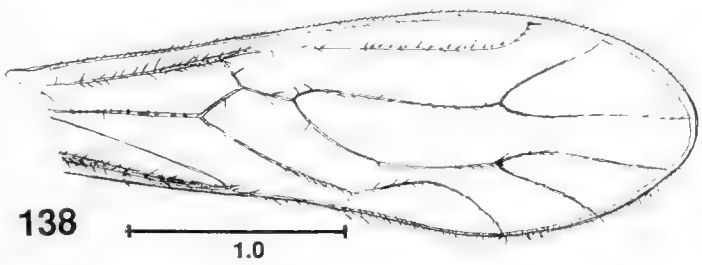
Description of male. Coloration (after ca 5 yr in alcohol). As female with following exceptions: head anteriorly cream, no discernible marks apart from antennal-orbit and post-orbital brown stripes. Brown pigment on mesothoracic terga rather paler than that on metathorax. Apical half of areola postica in fore wing (fig. 138) no different from rest of membrane; veins *rs* and r_{4+5} as dark as veins r_{2+3} and *m*.

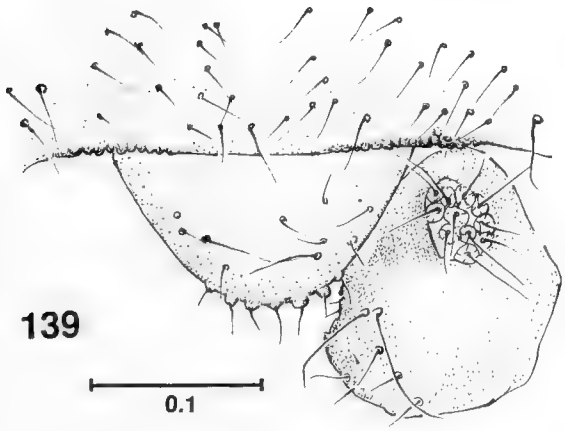
Morphology. IO:D = 2.7. Fore wing as fig. 138. Posterior border of ninth tergite with lateral rugose areas (fig. 139). Epiproct (fig. 139) semicircular, a row of 7 prominent setae on raised bosses along posterior margin, no apical field of papillae. Paraproct (fig. 139) with an oval field of 11 trichobothria. Hypandrium as fig. 140. Phallosome (fig. 141) angular with a pair of sclerotised rods, serrate on their inner faces over the fourth fifth of their length (from base to apex), projecting well beyond aedeagal arch to tip of outer parameres; penial bulb triangular, spiculate, most heavily along lateral margins.

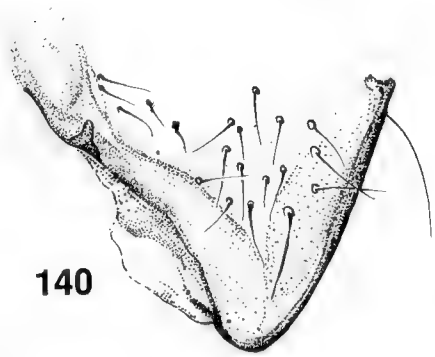
Dimensions. B 1.8, FW 3.12, HW 2.33, F 0.54, T 0.94, t_1 0.261, t_2 0.111, rt 4:1, ct 14, 0, f_1 0.529, f_2 0.308.

Remarks. New described this species from two females from Victoria, Australia. We here provide a description of a male from Wilsons Promontory.

The male of *P. rotundata*, like the female, is very similar to *P. crenulata* New, also known







Figures 138–141. *Pseudoscottiella rotundata*. Male: 138, forewing; 139, epiproct and paraproct; 140, hypandrium; 141, phallosome. Figures 139–141 to common scale.

from Victoria, although we have noted sexual dimorphism in coloration, whereas New noted no differences between the sexes of *P. crenulata*. In all female specimens of *P. rotundata* that we have examined (from Wilsons Promontory and elsewhere in Victoria) vein *rs* in the fore wing is paler than r_{2+3} and the medial branches, although this is not noted in New's description.

Pseudoscottiella tanei Smithers

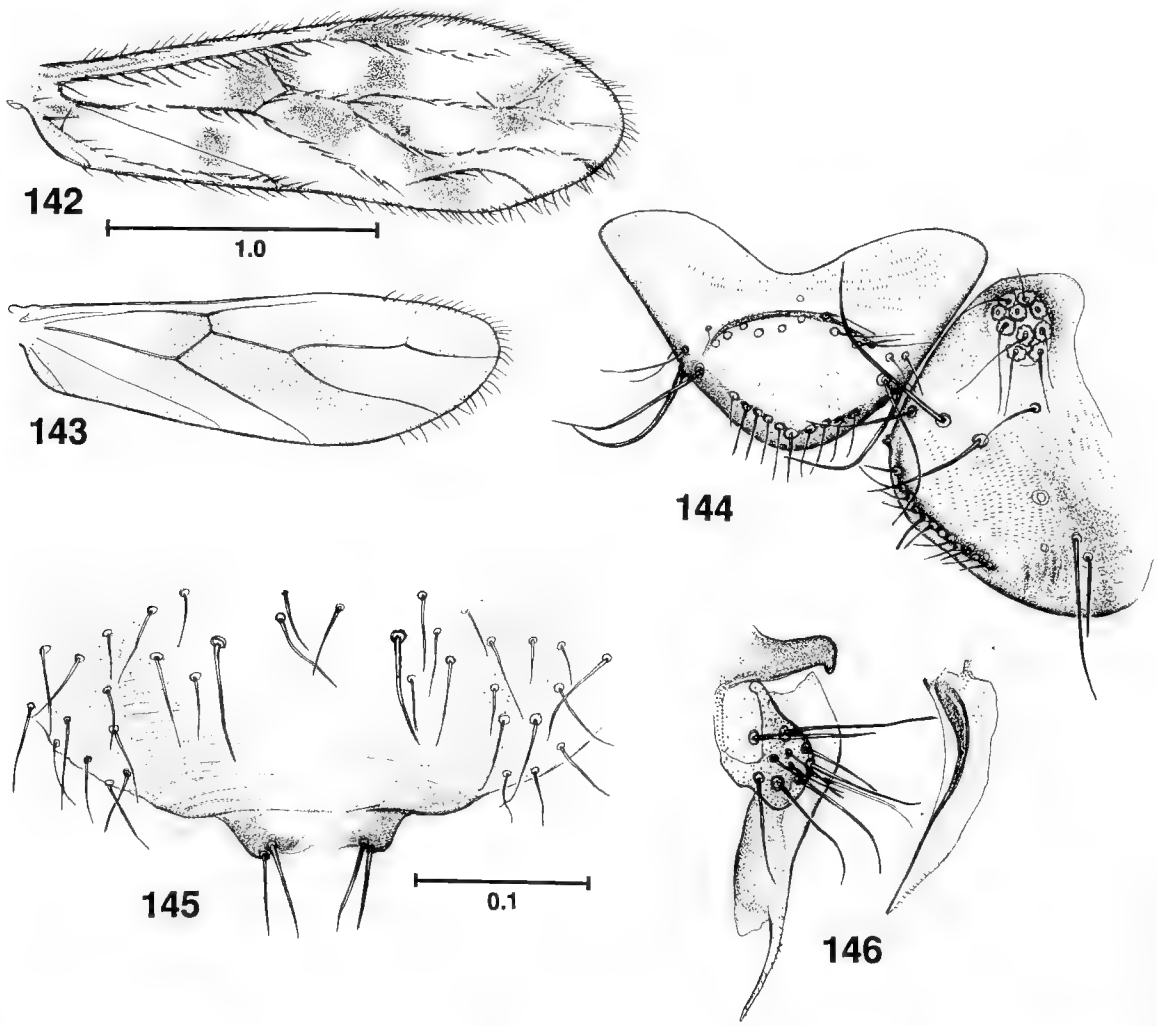
Figures 142–146

Pseudoscottiella tanei Smithers, 1977: 279.

Material examined. Specimen on which description based: ♀, Lilly Pilly Nature Track, tall open forest, 26–27 Jan 1986. Additional records (7♀, 13♂, 2 nymphs): site 7 (Nov, Dec 1985, Jan 1986), site 8 (Nov 1985, Jan 1986), site 10 (Mar 1985), site 28 (Apr 1990, Apr 1991), site 32, site 38.

Description of female. Coloration (after ca 5 years in alcohol). As male with the following exceptions: vertex cream with brown markings flanking orbit and epicranial suture. Ocelli centripetally black, antenna with scape and apical 4 segments of flagellum brown, otherwise very pale buff. Legs wholly pale cream except extreme basal margin of coxae. Fore wing (fig. 142) with brown mark in cell *M+Cu* not extending anteriorly to cell margin. Hind wing (fig. 143) with faint brown pattern. Abdomen dark grey-brown.

Morphology. IO:D = 5.8. Generally as male, antenna strongly setose. Epiproct (fig. 144) with



Figures 142–146. *Pseudoscottiella tanei*. Female: 142, forewing; 143, hindwing; 144, epiproct and paraproct; 145, subgenital plate; 146, gonapophyses. Figures 142, 143 and 144- -146 to common scales.

distinctive pattern of ciliation. Paraproct (fig. 144) with oval field of 10 trichobothria. Subgenital plate (fig. 145) with broad shallow apical lobe, itself incipiently bilobed, with a pair of stout setae each side of distal margin, lateral areas of lobe sclerotised. Gonapophyses (fig. 146): dorsal valve with short subapical lobe; outer valve small, rounded, heavily setose.

Dimensions. B 2.1, FW 2.12, HW 1.70, F 0.44, T 0.69, t_1 0.166, t_2 0.087, rt 1.9:1, ct 9, 0, f_1 0.269, f_2 0.182.

Remarks. This species was hitherto known only from a single male. We here provide a description of the female.

Found at Wilsons Promontory in tall open (site 7) and closed (site 8) forest as well as coastal vegetation. Discovery of females of this species, which can be clearly associated with males satisfying the description of Smithers (1977), shows this species to be sexually dimorphic in head pattern, antennal coloration and in small features of fore wing pattern, particularly the continuous hyaline area posterior to vein *m+cu*. In female genitalia *P. tanei* closely resembles *P. yenoides* (below). *P. yenoides* and *P. yeni* New are the only other two species of this genus known from continental Australia with patterned wings; although the pattern is similar to that of *P. tanei* in general features, in neither of these species does the pigment pattern extend to cell R_3. Macropterous and brachypterous females have been collected.

Pseudoscottiella yenoides sp. nov.

Figures 147–157

Material examined. Holotype ♀: Mt Sugarloaf, *Acacia melanoxylon* Kinglake National Park, Victoria, 30 Apr 1989; allotype ♂, 2♀ and 1♂ paratypes: same data as holotype (K73689–K73693). Additional records (1♀): site 17 (Jan 1985).

Description of female. Coloration (after ca 1 year in alcohol). Head creamy-buff with following exceptions: eyes black; pattern of brown spots flanking each orbit on vertex, pale brown along posterior of vertex; frons postclypeus, labrum and gena brown; ocelli without brown annuli. Apical half of flagellum pale brown. Thorax with dark brown dorsa having wide cream interpigmental areas. Thorax laterally and ventrally brown. Legs cream, t_2 dark brown apically. Fore wing (fig. 147) with distinct dark brown pigment pattern, anal cell hyaline. Hind wing (fig. 148) with pale brown pigment in basal cells, including cell *M*; cells R_1, R_3 and R_5 hyaline. Abdomen cream, genital segments dark.

Morphology. IO:D = 5.2. Claw without apical tooth. Epiproct (fig. 149) with median transverse row of setae, preapical row of shorter setae; apical margin thickened. Paraproct (fig. 149) with oval field of 10 trichobothria, single divided hyaline cone on inner apical border. Subgenital plate (fig. 150) slightly bilobed apically, sub-lobes with 2 and 3 stiff setae; area between sub-lobes spiculate. Gonapophyses (fig. 151, ventral valve broken and attached to subgenital plate) with outer valve ovoid bearing 8–9 setae, some very long; dorsal valve with short subapical lobe and spiculate apical tine.

Dimensions. B 2.45, FW 2.42, HW damaged, F 0.48, T 0.76, t_1 0.182, t_2 0.095, rt 1.9:1, ct 10, 0, f_1 0.324, f_2 0.186.

Description of male. Coloration (after ca 1 yr in alcohol). As female with following exceptions: ocelli with dark brown margins, epicranial suture dark brown, antenna brown. Coxae of meso- and metathoracic legs brown basally. Fore wing (fig. 152) and hind wing (fig. 153) hyaline.

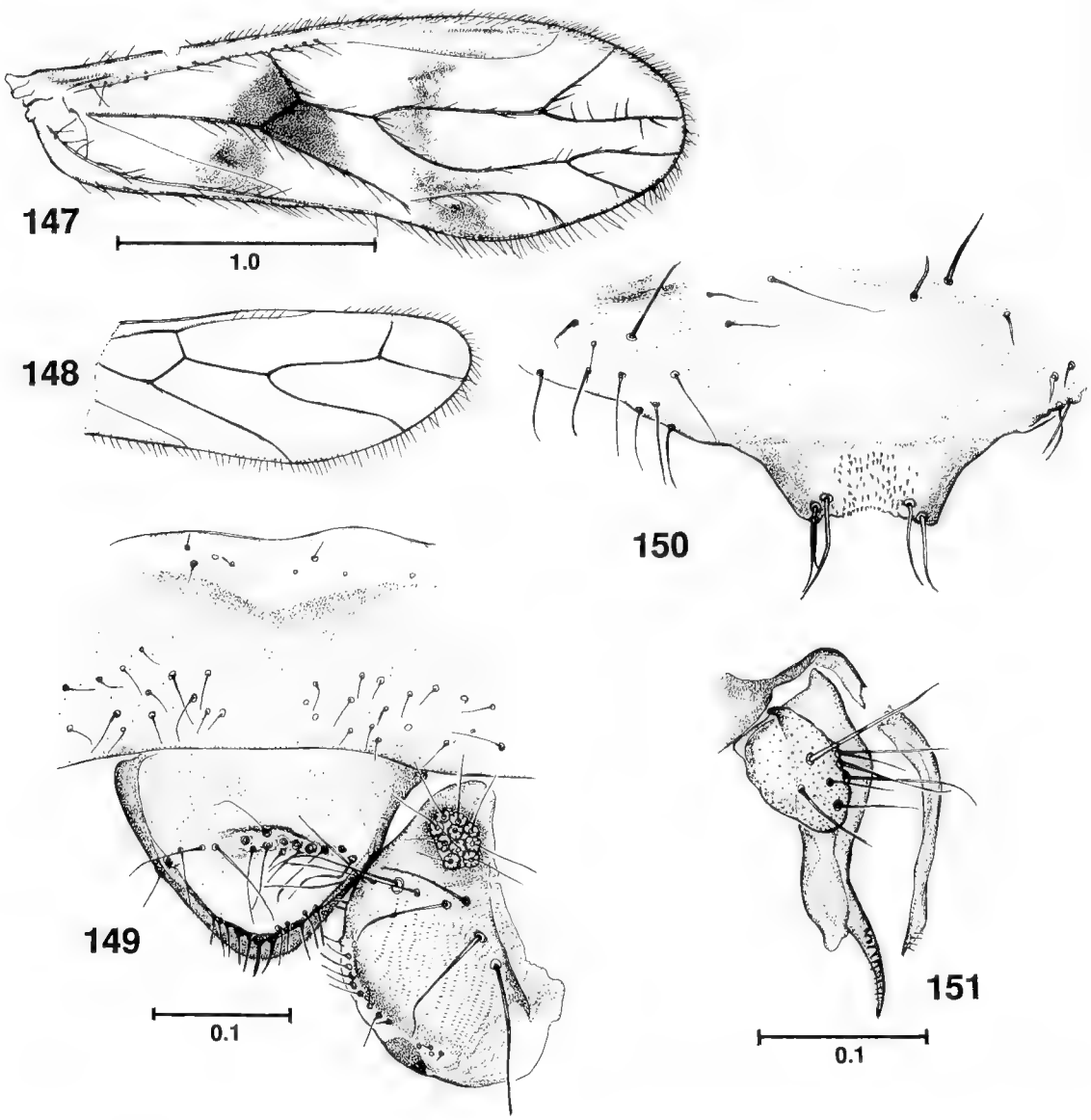
Morphology. IO:D = 2.2. Epiproct (fig. 154) hexagonal with 2 sides very short, thus almost square, a row of 6 close-set setae along posterior margin and 4–5 small fine scattered setae subapically; surface over apical sixth rugose with row of close-set spines along apical margin; 1 very long seta at each of the 4 posterior angles. Paraproct (fig. 155) with field of 10 trichobothria, duplex cone and 2 associated small setae on inner face, larger setae some distance away on inner face. Hypandrium (fig. 156) simple, rounded, setose. Phallosome (fig. 157) with pair of long, straight rods.

Dimensions. B 2.1, FW 3.22, HW 2.48, F 0.48, T 0.92, t_1 damaged, t_2 missing, f_1 = 0.545, f_2 = 0.316.

Remarks. Since only a single female was collected (from *Leptospermum laevigatum*) at Wilsons Promontory, but both sexes were collected at Kinglake, Victoria, the two Kinglake specimens were selected as types.

Pseudoscottiella yenoides is closely similar in body and wing pattern to *Pseudoscottiella yeni* New, also known from Victoria (Healesville). Females of *P. yenoides* may be distinguished by the hyaline anal cell of the fore wing combined with the more extensive transverse fascia in the apical half of the fore wing, cell R_5 being included in this pigmented band.

The pair of rods in the phallosome of *P. yenoides* are shorter than those of *P. rotundata*



Figures 147–151. *Pseudoscottiella yenoides*. Female: 147, forewing; 148, hindwing; 149, epiproct and paraproct; 150, subgenital plate; 151, gonapophyses. Figures 147, 148 and 150 and 151 to common scales.

and *P. crenulata*, and like those of *P. tanei*, which are also short, have a short basal apophysis directed towards the mid-line at right angles to the axis of the rod. The apical rugose field of the male epiproct is also present in *P. tanei*, but is not mentioned in the description of *P. crenulata*, and is absent in *P. rotundata*. Thus on male genitalia there are two pairs of species: *P. crenulata* and *P. rotundata*, and *P. yenoides* and *P. tanei*. The male of *P. yeni* is unknown. *P. tanei* is the only continental Australian species of *Pseudoscottiella* in which the male is known to have patterned fore wings.

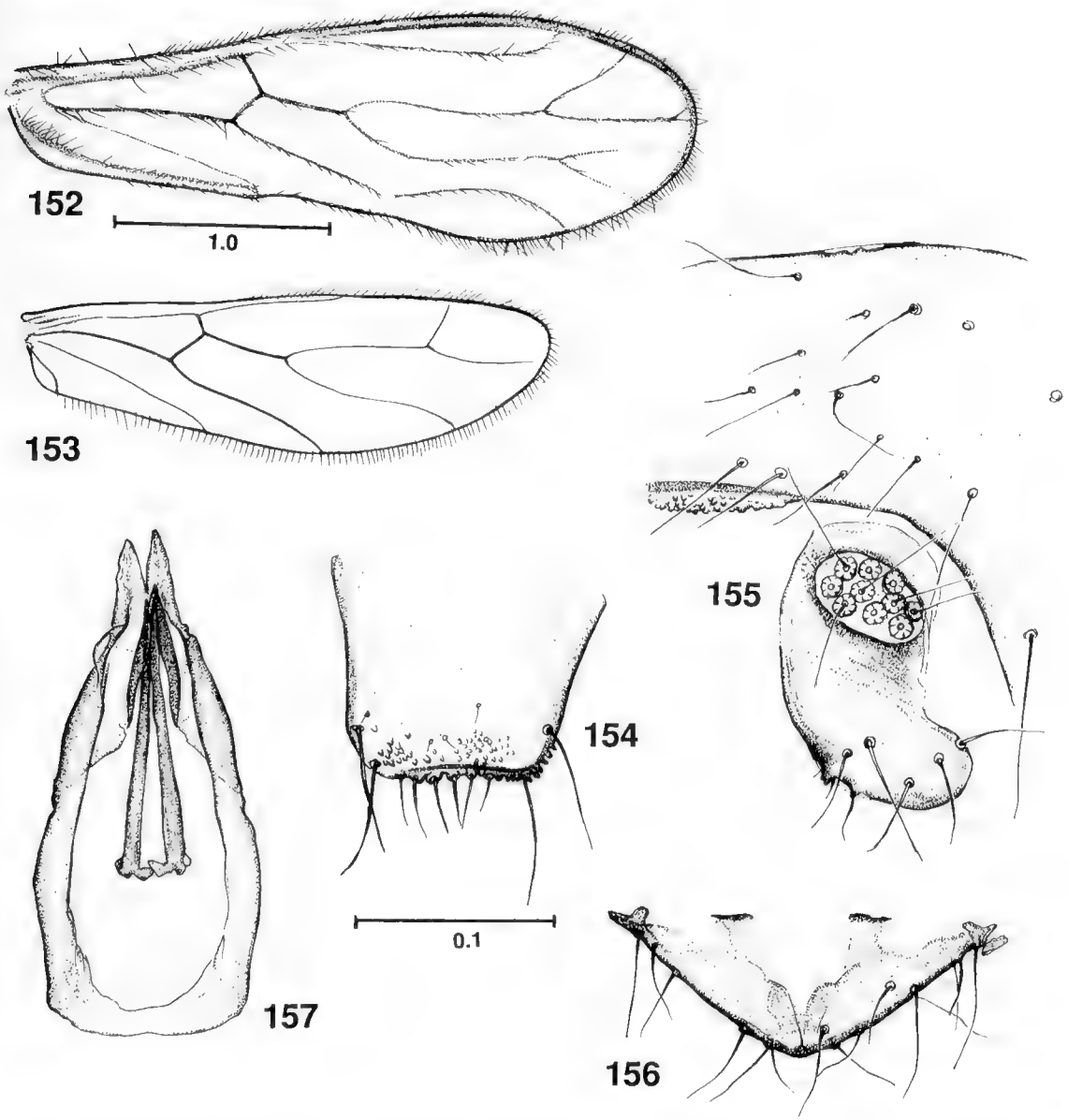
Philotarsidae Pearman

Aaroniella Mockford

Aaroniella Mockford, 1951: 102. Type species: *Elipsocus maculosus* Aaron.

Aaroniella rawlingsi Smithers

Aaroniella rawlingsi Smithers, 1969: 324.



Figures 152–157. *Pseudoscottiella yenoides*. Male: 152, forewing; 153, hindwing; 154, epiproct; 155, paraproct and ninth tergite; 156, hypandrium; 157, phallosome. Figures 152, 153 and 154–157 to common scales.

Material examined. 86♀, 32♂, 16 nymphs: site 14 (Apr 1984, Apr 1990, Jan 1991), site 15 (Apr 1984, Jan 1985), site 33, site 34.

Remarks. A. rawlingsi is widespread across southern Australia, being known from Western Australia, South Australia, NSW, Victoria, the Bass Strait islands and Tasmania. It was originally described from New Zealand. Found here on *Melaleuca ericifolia* (site 14), on open heath (site 15) and on mangroves (sites 33 and 34).

Haplophallus Thornton

Haplophallus Thornton, 1959: 336. Type species: *Haplophallus orientalis* Thornton.

Haplophallus sinus Thornton and New

Haplophallus sinus Thornton and New, 1977: 20.

Material examined. 363♀, 218♂, 36 nymphs: site 1 (Jan, Feb, Mar, Nov 1985, Jan, Feb 1986), site 3 (Feb 1986), site 4 (Mar, May, Nov 1985, Feb 1986), site 5 (May 1985, Feb 1986), site 8 (Jan 1991), site 9 (Nov,

Dec 1985, Jan, Feb 1986), site 10 (Jan, May, Sep, Oct, Nov 1985, Jan, Feb 1986), site 12, site 13, site 14 (Apr 1984, Apr 1990, Jan 1991), site 15 (Apr 1984), site 16, site 18, site 20, site 21, site 23, site 24, site 25, site 26, site 27, site 29, site 30, site 31, site 32, site 34, site 36, site 37, site 40, site 42, site 44.

Remarks. This common, widespread species has been recorded previously from Wilsons Promontory (Thornton and New, 1977), and occurs in practically all habitats sampled except bracken and closed forest.

Latrobiella Thornton

Latrobiella Thornton, 1981: 433. Type species: *Haplophallus bundoorensis* New.

Latrobiella fenestrata sp. nov.

Figures 158–166

Material examined. Holotype ♀ : Lilly Pilly Nature Track, closed forest, 21–23 Feb 1986; allotype ♂, 2♂ paratypes: holotype locality, 1–3 Nov 1985 (K73694–K73697). Additional records (1♀, 2♂): site 25.

Description of female. Coloration (after ca 5 yr in alcohol). Head generally cream with following brown marks: usual pattern of patches on vertex and mesial to orbits; triangular patch anterior to ocellar protuberance dark brown with smaller lighter brown patch each side; vertex-frons suture lined with brown, a brown line from suture to orbit. Gena brown posteriorly. Clypeal striae merging medially. Labrum dark brown. Antenna brown, apex of pedicel cream, flagellar segments without cream apices. Maxillary palps light brown, apical segment dark brown. Eyes black, ocelli clear with black centripetal borders. Thoracic nota brown with cream margins, cream median line includes scutella. Thoracic pleura dark brown over dorsal third, otherwise cream with narrow brown band just above ventral edge, side of thorax thus appears longitudinally banded in brown and cream. Procoxa cream, meso and metacoxa brown; trochanter cream; femur pale buff with small brown isolated spots; hind femur brown over proximal third; tibia pale buff; tarsal segments brown. Fore wing (fig. 158) with distinctive pattern of dark brown and hyaline areas, reticulated hyaline pattern in cells *R* and *M+Cu*; bases of setae surrounded by brown pigment, posterior margin of wing bounding areola postica and cells M_3 and M_2 dark brown. Hind wing (fig. 159) hyaline with pale brown band around posterior margin apically, cell Cu_2 brown. Abdomen dorsally buff, terga posteriorly with narrow brown band incorporating small light buff patches; first and second terga with broad cream band in midline, brown more laterally, remaining terga with brown band in midline; abdomen ventrally light brown, sternites 6 to 8 darker brown; apex of abdomen cream.

Morphology. IO:D = 5.5. Apical segment of antenna not attenuated but with single apical seta (fig. 160). Claw with small preapical tooth. In fore wing vein cu_2 bare, vein setae in single rank except veins *r*, *an* and basal section of cu_1. Additional branch of vein *m+cu* curves distally to almost meet vein cu_1, partially enclosing a circular additional cell (in both wings); wing outline slipper shaped. Setae on hind wing veins: r_1 1, *rs* 0, r_{2+3} 0, r_{4+5} 10, *m* 1, cu_1 0. Epiproct (fig. 161) rectangular, setose over apical half, 2 longer setae on posterior margin. Paraproct (fig. 161) with field of 28 trichobothria and 1 seta not in rosette socket. Subgenital plate (fig. 162) with apical sclerite bearing 4 small setae on distal margin. Gonapophyses (fig. 163): outer valve triangular, rounded posteriorly, setose; ventral valve narrow with fine recurrent spinelets apically; dorsal valve with slightly raised field of minute spines on distal margin.

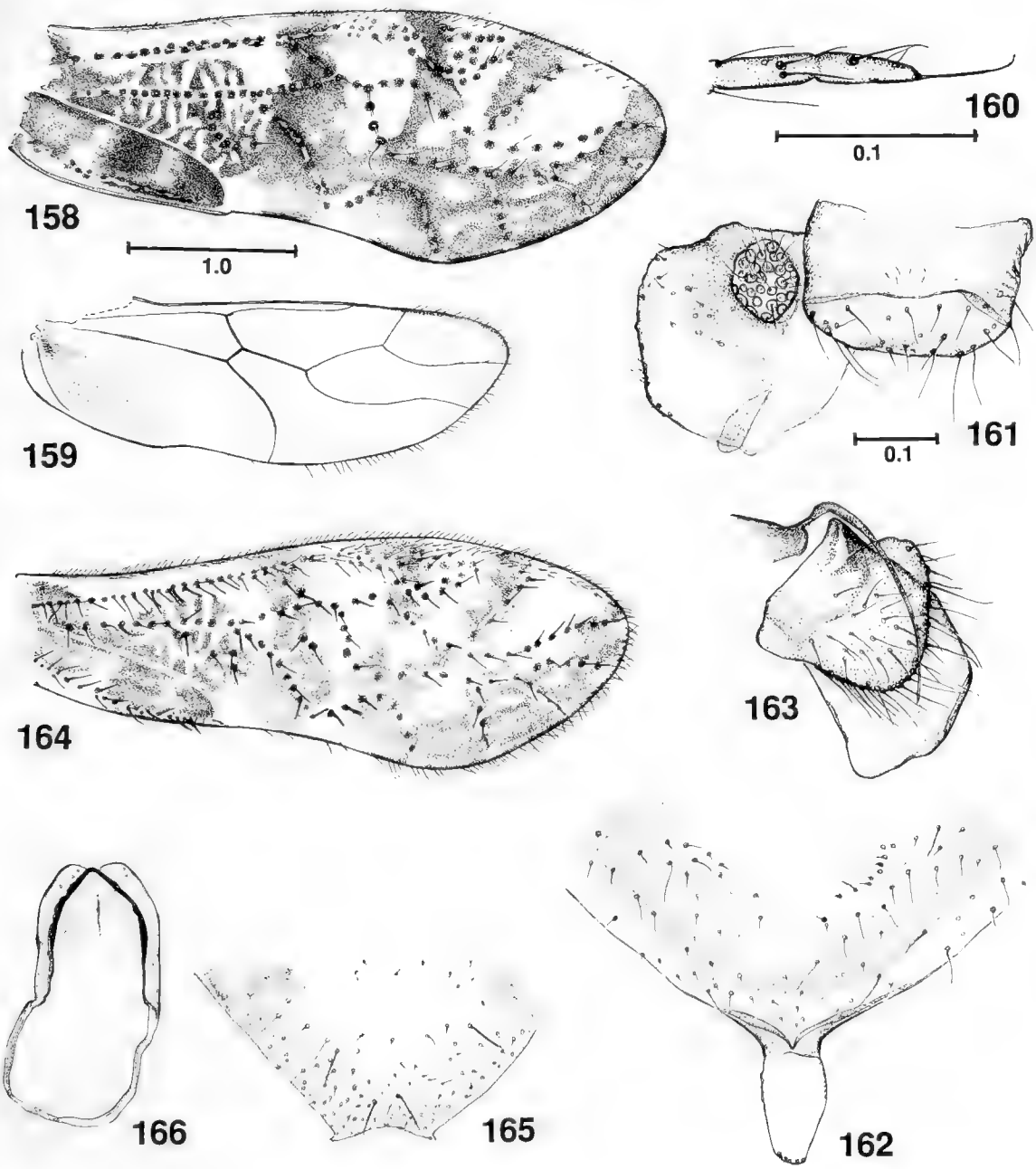
Dimensions. B 2.8, FW 3.84, HW 2.89, F 0.63, T 1.29, t_1 0.411, t_2 0.071, t_3 0.071, rt 5.8:1:1, ct 18, 0, 0, f_1 0.466, f_2 0.411.

Description of male. Coloration (after ca 5 yr in alcohol). As female.

Morphology. IO:D = 5.0. Apical segment of antenna not attenuated, with 2 apical setae; flagellar setae longer than in female. Claw with small preapical tooth. Fore wing (fig. 164): vein cu_2 bare; addition vein in cell *M + Cu* not discernible but 3 setae within cell in position of vein in female. Setae on hind wing veins: r_1 0, *rs* 0, r_{2+3} 0, r_{4+5} 13, *m* 7, cu_1 0. Epiproct with curved posterior margin, setose. Paraproct with field of 36 trichobothria and 2 setae not in rosettes. Hypandrium (fig. 165) incised basally, apically emarginate with a pair of short pointed curved hooks, setose, setae near apical margin short, fine; a close-set subapical pair of strong setae and a more widely set pair in the middle of hypandrium. Phallosome (fig. 166) lacking sclerites within frame.

Dimensions. B 2.2, FW 3.72, HW 2.74, F 0.65, T 1.39, t_1 0.434, t_2 0.079, t_3 0.087, rt 5.5:1:1.1, ct 20, 0, 0, f_1 0.711, f_2 0.592.

Remarks. This species exhibits a mosaic of character states found in *Latrobiella* and *Haplophallus*. It is *Haplophallus*-like in: the form of the hypandrium apex, vein cu_2 in the fore wing bare,



Figures 158–166. *Latrobiella fenestrata*. Female: 158, forewing; 159, hindwing; 160, apical segment of antenna; 161, epiproct and paraproct; 162, subgenital plate; 163, gonapophyses. Male: 164, forewing; 165, hypandrium; 166, phallosome. Figures 158, 159 and 164 and 161–163, 165 and 166 to common scales.

antennal apex not attenuated. *Latrobiella*-like characters are: the form of the subgenital plate, the outer and dorsal valves of the female gonapophyses, female antennal apex with a single long, stout seta, fore wing setae sited on dark spots. The hypandria of *Latrobiella mouldsi* Thornton and New from north Queensland and to a lesser extent *Latrobiella ornatus* Thornton and New from NSW and Queensland, *Latrobiella alticola* Thornton and Smithers and *Latrobiella setosa* Thornton and Smithers from the high mountains of New Guinea, are of the *Haplophallus* type in that they are not notched along the posterior margin and have rather angu-

lar postero-lateral corners, which in *L. mouldsi* are incipiently recurved. *L. fenestrata* therefore would not be unique in the genus *Latrobiella* in having a *Haplophallus* type of hypandrium. However, in having vein cu_2 of the fore wing bare, and in the characteristic wing pattern, including a reticulated network of dark pigment and hyaline areas in cell $M + Cu$, it differs from all other known Australian species of *Latrobiella*, but is similar to *Latrobiella parda* (Thornton, Wong and Smithers) from New Zealand. *L. fenestrata* can be distinguished from *L. parda* in having the fore wing vein setae sited on dark spots, and in the form of the subgenital plate.

Latrobiella guttata (Tillyard)

Philotarsus guttatus Tillyard, 1923: 181.
Haplophallus guttatus. — Smithers, 1969: 322.
Latrobiella guttata. — Thornton, 1981: 433.

Material examined. 28♀, 8♂, 23 nymphs: site 3 (Jan, Dec 1985, Jan, Feb 1986), site 4 (Jan 1985), site 10 (Jan, Feb 1986), site 15 (Jan 1985), site 40.

Remarks. This species, found here in heathland and dune vegetation, is widely distributed in southern mainland Australia, Tasmania and New Zealand.

Elipsocidae Pearman

Drymopsocus Smithers

Drymopsocus Smithers, 1963a: 36. Type species: *Drymopsocus brunneus* Smithers.

Drymopsocus brunneus Smithers

Drymopsocus brunneus Smithers, 1963a: 36.

Material examined. 7♀: site 8 (Apr, May, Nov 1985, Jan 1986, Jan 1991), site 19.

Remarks. This is the first record of *D. brunneus* since its description from NSW material. Females only were collected at Wilsons Promontory, in closed forest (site 8) and tall open forest (site 19). All were macropterous, with a fore wing length of about 1.9 mm.

Pentacladus Enderlein

Pentacladus Enderlein, 1906: 408. Type species: *Pentacladus eucalytpi* Enderlein.

Pentacladus eucalypti Enderlein

Pentacladus eucalytpi Enderlein, 1906: 408.

Material examined. 11♀, 10♂, 1 nymph: site 19, site 24 (dead *Eucalyptus* leaves), site 28 (Apr 1990, Apr 1991 – nearby dead *Eucalyptus* leaves).

Remarks. P. eucalypti is known from all eastern Australian states from Tasmania to Queensland, and from South Australia. It has also been recorded from New Zealand.

Propsocus McLachlan

Propsocus McLachlan, 1866: 352. Type species: *Propsocus pallipes* McLachlan.

Propsocus pulchripennis (Perkins)

Stenopsocus pulchripennis Perkins, 1899: 83.
Propsocus pulchripennis. — Zimmerman 1957: 179.

Material examined. 1♀: site 2 (Mar 1985).

Remarks. This widespread species recorded in Australia from all states except the Northern Territory was found here in low eucalypt woodland.

Spilopsocus Smithers

Spilopsocus Smithers, 1963b: 894. Type species: *Spilopsocus ruidis* Smithers.

Spilopsocus masseyi New

Spilopsocus masseyi New, 1971: 226.

Material examined. 105♀, 36♂, 12 nymphs: site 1 (Feb, Mar, Apr, May, Jul, Aug, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 2 (Apr 1985, Jan 1986), site 3 (Jan 1986), site 10 (Apr, May, Sep, Oct, Nov, Dec 1985, Jan, Feb 1986), site 12, site 14 (Apr 1984, Apr 1990), site 15 (Apr 1984), site 18, site 20, site 21, site 29, site 32, site 33, site 34, site 40.

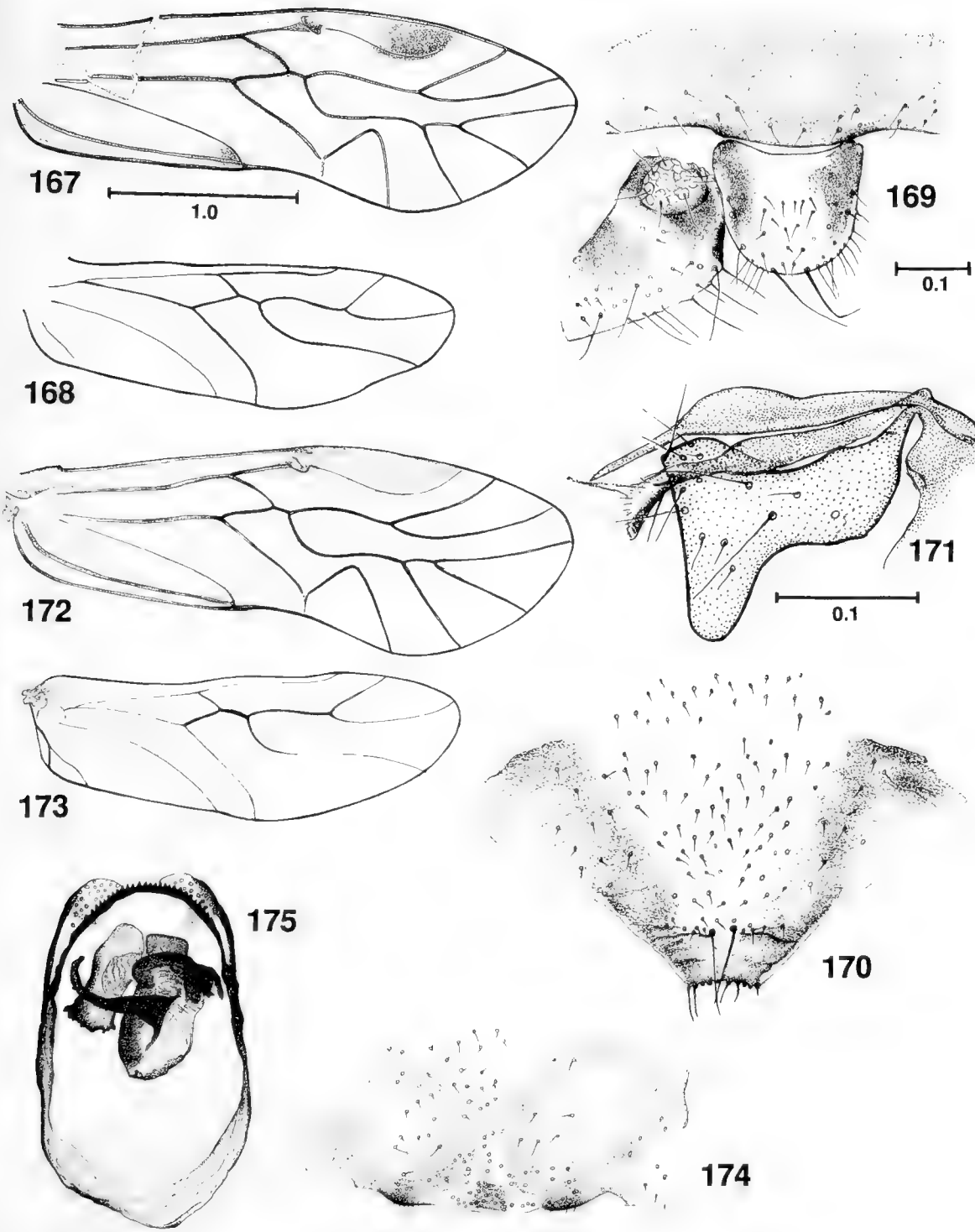
Remarks. Found in coastal vegetation at Wilsons Promontory, including *Casuarina* (sites 1 and 21) and mangroves (sites 33 and 34). *S. masseyi* has been recorded from South Australia, NSW, Victoria and the Bass Strait islands.

Spilopsocus serratus sp. nov.

Figures 167–175

Material examined. Holotype ♀: Telegraph Saddle, low eucalypt woodland, 27–29 Mar 1985; allotype ♂: Little Oberon Bay Track, *Casuarina stricta*, 8–10 Sep 1985; 2♀, 1♂ paratypes: allotype locality, 26–27 Jan 1986 (K73698–K73702). Additional records (2♀, 4♂): site 1 (Jan, Feb 1986), site 2 (Nov 1985, Feb 1986).

Description of female. Coloration (after ca 5 yr in alcohol). Epicranium buff with brown markings either side of median epicranial suture and brown spots, some confluent, adjacent to eyes. Frons with broad brown band from ocellar protuberance to antennal socket, darker median stirrup mark touching epistomial suture, which is dark brown. Striae on postclypeus obvious, no medial darkening. Labrum brown, maxillary palps pale greyish brown, distal segment dark brown. Gena with diagonal line from below



Figures 167–175. *Spilopsocus serratus*. Female: 167, forewing; 168, hindwing; 169, epiproct and paraproct; 170, subgenital plate; 171, gonapophyses. Male: 172, forewing; 173, hindwing; 174, hypandrium; 175, phallosome. Figures 167, 168, 172 and 173 and 169, 170, 174 and 175 to common scales.

orbit to below antennal socket, delimiting a pale buff posterior area from brown pigment between eye and antennal socket. Antenna brown, flagellar segments with white apices, eyes black. Ocellar protuberance brown, ocelli with dark centripetal crescents. Antedorsum and lateral lobes of mesothorax brown, buff adjacent to sutures; scutellum darker than lobes but with white median mark. Metathoracic terga and thoracic pleura brown. Legs with coxa, femur and tarsal segments brown, trochanter pale, tibia pale buff with dark brown basal tenth and apical fifth. Fore wing (fig. 167) hyaline with dark brown patch covering apical half of pterostigma, stigmasac brown, narrow light brown clouding around sections of veins *m* and *r* basal to their fusion, faint brown cloud over distal angle of cell Cu_2, cell *An* fuscous over basal one-third. Hind wing (fig. 168) hyaline. Abdomen dorsally cream, terga 5 to 7 brown, abdomen thus has broad brown transverse band about half way along its length, fourth tergite with some brown pigment over median third; ventrally grey-brown, cream along sutures; apical sclerites dark brown.

Morphology. IO:D = 4.8. Claw with preapical tooth. Fore wing glabrous. Hind wing with veins *rs* and *m* fused for a length, vein cu_1 not strongly recurved at wing margin, glabrous. Epiproct (fig. 169) rounded posteriorly, setose, with 4 longer stout setae equally spaced just anterior to posterior margin. Paraproct (fig. 169) with round field of 25 trichobothria. Subgenital plate (fig. 170): apex broad, slightly concave, bearing row of 10 prominent setae; a pair of very long setae anterior to this row, intervening area glabrous; remainder of plate with small fine scattered setae. Gonapophyses (fig. 171): ventral valve expanded midway along length; dorsal valve with divided apex; outer valve boot-shaped.

Dimensions. B 2.5, FW 2.95, HW 2.27, F 0.58, T 1.08, t_1 0.269, t_2 0.071, t_3 0.099, rt 3.8:1:1.4, ct 15, 0, 0, f_1 0.521, f_2 0.316.

Description of male. Coloration (after ca 5 yr in alcohol). As female with following exceptions: flagellum wholly brown, pterostigma of fore wing wholly pale brown (fig. 172).

Morphology. IO:D = 2.5. Claw with preapical tooth. Fore wing glabrous. Hind wing (fig. 173) with *rs* and *m* fused for a length, vein cu_1 not strongly recurved at wing margin, glabrous. Epiproct triangular, narrow, lateral margins sclerotised. Paraproct with field of 36 trichobothria. Hypandrium (fig. 174): sclerotisations on postero-lateral margins, membranous gusset medially on posterior margin with an isolated sclerotised area in midline. Phallosome (fig. 175) with smoothly rounded, serrate, aedeagal arch; large stout sclerites within phallic frame.

Dimensions. B 2.0, FW 3.45, HW 2.63, F 0.58, T 1.29, t_1 0.371, t_2 0.079, t_3 0.103, rt 4.7:1:1.3, ct 16, 1, 0, f_1 0.735, f_2 0.423.

Remarks. Collected from *Casuarina stricta* (site 1) and low eucalypt woodland (site 2).

Eight *Spilopsocus* species are now described, four from Australia, one from Lord Howe Island and three from New Zealand. *S. serratus* differs from other described species, except *Spilopsocus parvus* Smithers and Thornton (Lord Howe I.), in the distinctive serrate aedeagal arch of the phallosome, and possesses more apical setae on the terminal lobe of the subgenital plate (10) than any other described species (from 4 in *Spilopsocus ruidis* Smithers to 8 in *S. parvus*). Vein cu_2 of the hind wing is curved towards the wing margin to meet it at right angles or more, as in other propsocine genera, in all species in which this condition is noted (not mentioned or figured in descriptions of the Australian species *Spilopsocus masseyi* New and *Spilopsocus colliensis* Smithers). The fore wing pattern is slight and simple, not complex as in *S. ruidis, S. masseyi, Spilopsocus annulatus* Smithers (New Zealand) and *S. colliensis*, and does not include a basal transverse fascia as in *S. parvus* and *Spilopsocus stigmaticus* Smithers (New Zealand). The areola postica in the fore wing is high and trianguloid, as in *S. parvus, S. stigmaticus* and *Spilopsocus avius* Smithers (New Zealand), in contrast to the low semi-circular condition seen in *S. masseyi* and *S. annulatus*.

Psocidae Stephens

Blaste Kolbe

Blaste Kolbe, 1883b: 79. Type species: *Blaste juvenilis* Kolbe.

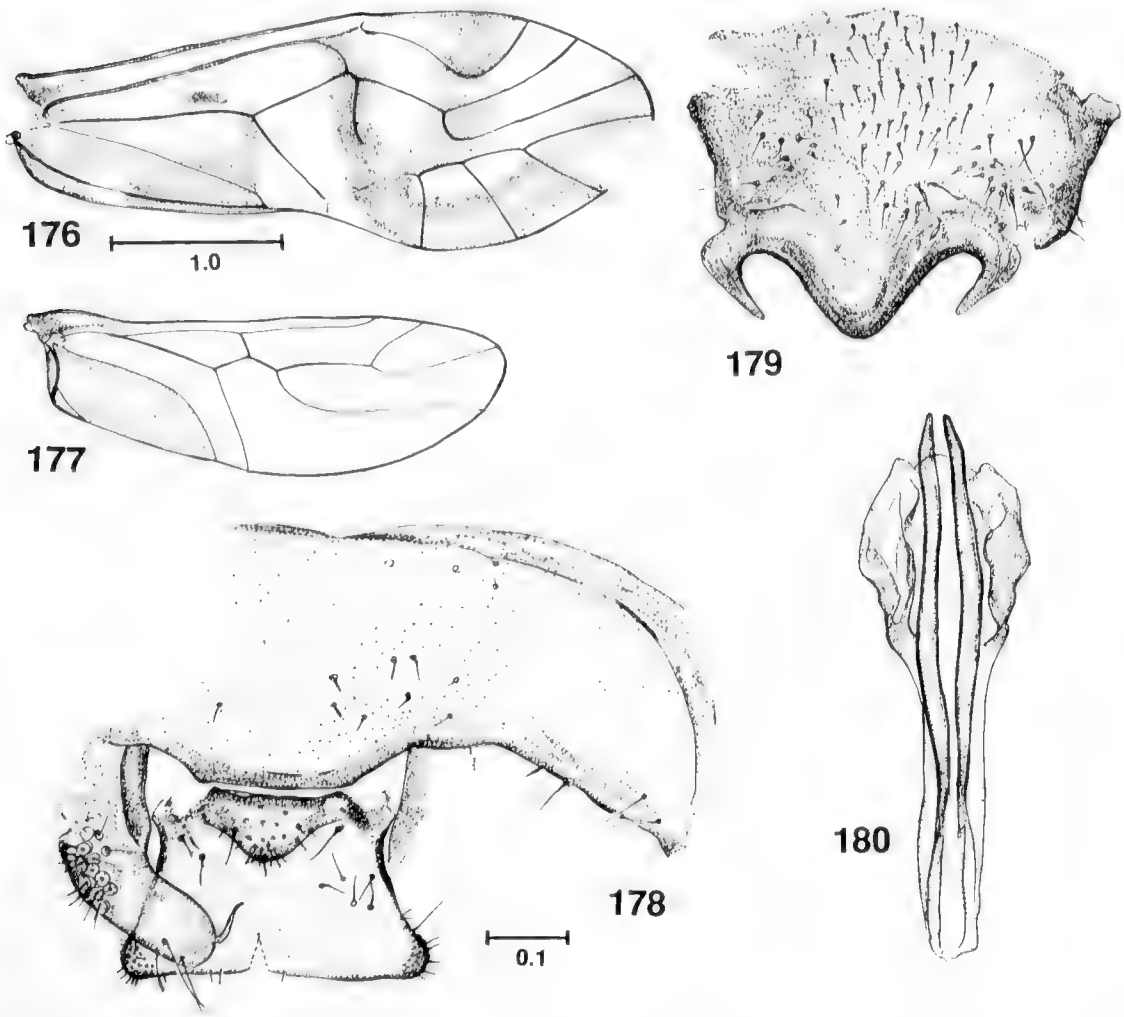
Blaste bistriata sp. nov.

Figures 176–180

Material examined. Holotype ♂: Stockyard camp, wooden fence, 7 Apr 1991; paratype ♂: same data as holotype (K73703, K73704).

Description of male. Coloration (after ca 2 mo in alcohol) Eyes black. Ground color of head creamy-buff, usual vertex markings and ocellar protuberance brown; narrow brown band extends laterally from posterior of ocellar protuberance to lateral vertex marks, wider brown band parallel to this extends in front of ocellar

protuberance to point posterior to antennal socket; brown stirrup mark in middle of frons; ocelli with black centripetal margins; area between orbit and antennal socket brown; genae creamy-buff; clypeus brown, striae merging. These markings produce an effect such that the front of the head carries a broad median brown band which is crossed at right angles by 2 narrower brown bands thus isolating 3 pairs of creamy-buff areas, 2 on the vertex and 1 on the frons. Labrum brown. Scape, pedicel and basal flagellar segment pale brown, f_1 darkening apically; rest of flagellum dark brown. Maxillary palps with basal segment pale brown, apical segment dark brown, other segments brown. Thoracic terga brown with cream margins, pleural sclerites and coxae of legs brown except those associated with anterior leg creamy-buff. Trochanter and femur of hind leg cream, except distal quarter of femur brown; trochanter and femur of anterior leg cream shading to buff distally, those of middle leg buff. Tibiae light brown, darkening distally, tarsi brown. Fore wing (fig. 176) with characteristic brown and dark brown pigment pattern. Hind wing (fig. 177) with brown cloud in cubital cell. Abdominal terga with brown patches forming a broad interrupted dorsal stripe, these patches less continuous laterally; abdominal sterna cream with faint brown posterior transverse striae. Ninth



Figures 176–180. *Blaste bistriata*. Male: 176, forewing; 177, hindwing; 178, epiproct and paraproct; 179, hypandrium; 180, phallosome. Figures 176, 177 and 178–180 to common scales.

tergite, epiproct, paraprocts, hypandrium and phallosome brown.

Morphology. IO:D = 2.4, eyes offstanding. Clypeus, labrum and thoracic terga waxy. Outer edge of discoidal cell of fore wing concave; a hyaline lunule at margin of cells M_1, M_2 and M_3 (cell M_1 margin torn in holotype). Epiproct (fig. 178) small, rounded with 3 stout setae and field of smaller close-set setae apically; a very large dorsal flap, subrectangular, with sclerotised margins and with its rounded distal corners beset with low, pointed spines. Paraproct (fig. 178) with apical spine, and circular field of 38-40 trichobothria. Hypandrium (fig. 179) symmetrical, with rounded median lobe and pair of curved pointed horns. Phallosome (fig. 180) elongate, inner parameres straight, pointed; outer parameres sinuous, connected by membraneous tissue.

Dimensions. B 2.5, FW 3.68, HW 2.63, F 0.77, T 1.57, t_1 0.569, t_2 0.142, rt 4.0:1, ct 24, 3, f_1 0.768, f_2 0.691.

Female. Unknown.

Remarks. As summarised by Smithers (1984), on a number of genitalic and other characters, six Australian species of *Blaste* form a close-knit group, which may be a distinct generic grouping. *B. bistriata* is a seventh member of this group, and is most similar to *Blaste macrops* Smithers in hypandrial structure, and to *Blaste lunulata* New in male wing pattern. It differs from *B. macrops* (South Australia) in having extensively patterned fore wings, and from *B. lunulata* (Western Australia) in details of the pattern, the pattern in *B. bistriata* being simpler and in particular having less pigment in cell *R*. Other species of this group are *Blaste falcifer* Smithers and *Blaste panops* Smithers (Tasmania), *Blaste furcilla* New (Western Australia) and *Blaste tillyardi* Smithers (New Zealand, NSW, South Australia, Wilsons Promontory and other areas of Victoria).

Blaste forficula sp. nov.

Figures 181–184

Material examined. Holotype ♂: Stockyard camp, coastal vegetation, 7 Apr 1991 (K73705).

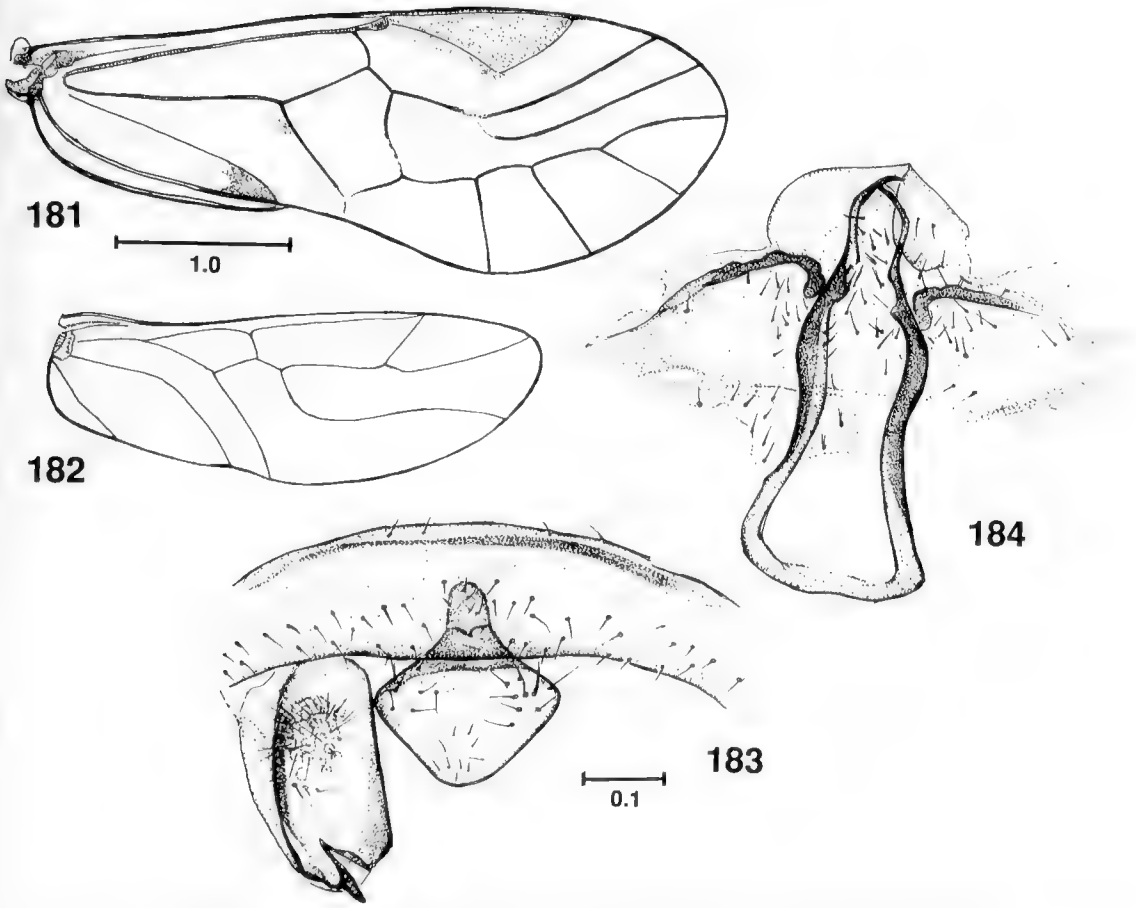
Description of male. Coloration (after ca 2 mo in alcohol). Head creamy-buff; eyes black. Posterior of vertex covered with brown pigment with irregular anterior border at level of posterior margin of eyes; ocellar protuberance creamy-buff, ocelli black; from each posterior ocellus transverse sinuous brown line extends to a point very close to anterior edge of eye where it bends anteriorly at right angles to fuse with a broader transverse band extending mesad to anterior ocellus. Anterior edge of frons with narrow brown band subparallel to the 2 mentioned above. Antennal socket ringed brown, faint brown band between this and orbit. Genae wholly creamy-buff. Postclypeus with faint brown parallel striae, labrum creamy-buff. Maxillary palps creamy-buff except apical segment brown, darkening distally. Antennae pale brown. Thoracic dorsa dark brown, margin cream, scutella cream. Sides of thorax below wing bases cream, narrow longitudinal brown band immediately above coxae, which are cream. Femora cream, posterior femur with apical brown spot; tibiae very pale buff with darker subapical ring; basal tarsal segment buff, apical segment darker. Fore wing (fig. 181) with sparse brown markings. Hind wing (fig. 182) hyaline. Abdomen cream.

Morphology. IO:D = 5.0. Epiproct (fig. 183) with tapering anterior extension, sclerotised lateral margins. Paraproct (fig. 183) with short, straight apical spine; with round field of 36-38 trichobothria. Hypandrium (fig. 184) semicircular, margin without setae or any ornamentation. Phallosome (fig. 184) angular and closed anteriorly, outer (?) parameres curved, forceps-like; inner (?) parameres straight, pointed, orientated laterally at right angles to long axis of frame.

Dimensions. B 2.8, FW 3.98, HW 2.88, F 0.71, T 1.57, t_1 0.458, t_2 0.142, rt 3.22:1, ct 21, 3, f_1 0.787, f_2 0.806.

Female. Unknown.

Remarks. In phallosome structure, epiproct and paraproct this species resembles *Blaste magnifica* Smithers (South Australia). The anterior prolongation of the epiproct is somewhat narrower in *B. forficula* and the posterior surface of the epiproct bears very small, short setae, whereas that of *B. magnifica* bears very long setae. The straight, pointed inner (?) parameres of *B. forficula* are directed laterally, not towards the midline as in *B. magnifica*. Moreover, the fore wing of *B. forficula* lacks the unusual mottled pattern of *B. magnifica* and veins cu_{1a} and cu_{1b} are in a straight line and are approximately equal in length; the pterostigma has a somewhat pointed vertex with a short spurvein whereas in *B. magnifica* a spurvein is evidently lacking. The eyes of *B. forficula* are not sited on short, thick stalks as in *B. magnifica*.



Figures 181–184. *Blaste forficula*. Male: 181, forewing; 182, hindwing; 183, epiproct and paraproct; 184, phallosome and hypandrium. Figures 181, 182 and 183 and 184 to common scales.

The affinities of this unusual species are difficult to assess. Although there are some resemblances to *B. magnifica* (for example in apical phallosome structure) there are clear differences (for example in fore wing, hypandrium and placement of eyes) and the question of their congeneric status will have to be considered carefully when the large heterogeneous genus *Blaste* is revised.

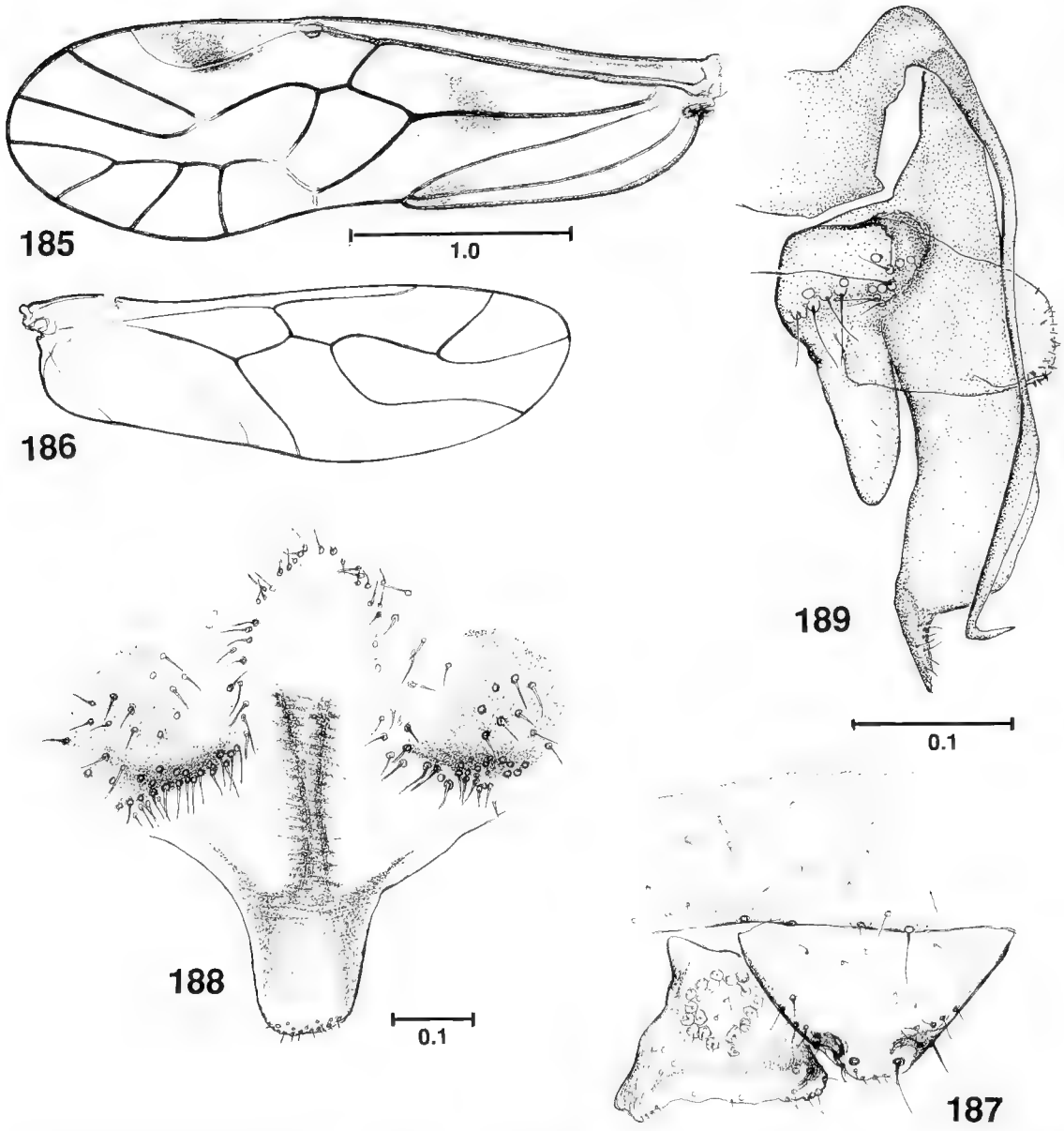
Blaste lignicola (Enderlein)

Figures 185–192

Psocus lignicola Enderlein, 1906: 401.
Euclismia lignicola. — Enderlein, 1925: 100. — New, 1971: 228–229.
Blaste (Euclismia) lignicola. — Badonnel, 1955: 253.
Blaste howicki New, 1974b: 290–291 (new synonymy).

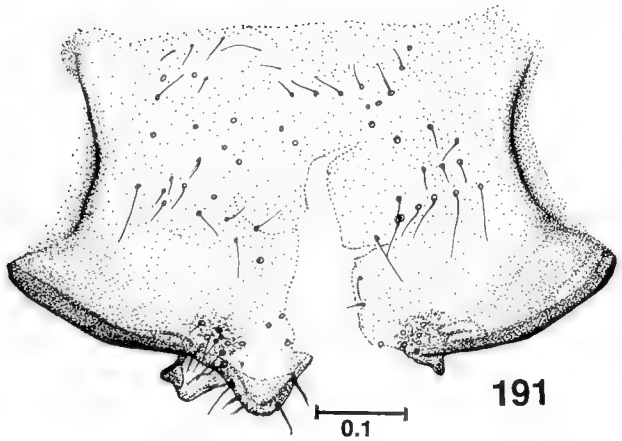
Material examined. Specimens on which descriptions based: ♀, ♂, Telegraph Saddle, low eucalypt woodland, 22–25 Jan 1985. Additional records (91♀, 49♂, 95 nymphs): site 1 (Mar, Apr, Dec 1985, Jan 1986), site 2 (Jan, Feb, May, Jun 1985, Jan 1986), site 3 (Feb 1986), site 4 (Dec 1985, Jan 1986), site 9 (Jun 1985, Jan 1986), site 10 (Mar, Dec 1985), site 11 (Apr, Dec 1985, Jan 1986), site 13, site 14 (Apr 1984, Jan 1991), site 15 (Apr 1984), site 22, site 23, site 27, site 29, site 30, site 31, site 32, site 33, site site 35, site 37, site 41, site 43, site 44 (nymph only).

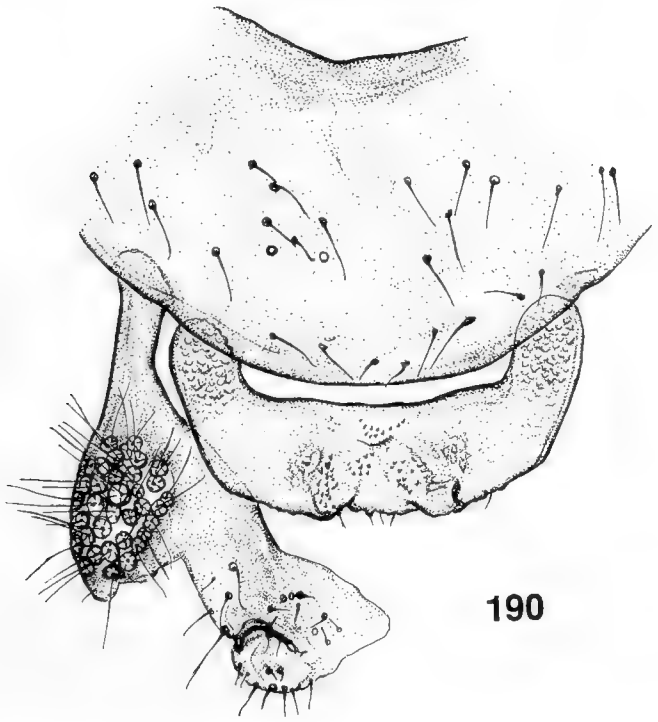
Further description of female. Coloration (after ca 5 yr in alcohol). Head cream with the following markings brown: small patches along posterior of vertex, mesad of orbits and each side of epicranial suture; band of epicranial suture patches broadens anteriorly to form a Y. Each side of vertex posteriorly, an isolated grey-brown patch, a grey-brown patch of similar size



Figures 185–189. *Blaste lignicola*. Female: 185, forewing; 186, hindwing; 187, epiproct and paraproct; 188, subgenital plate; 189, gonapophyses. Figures 185, 186 and 187 and 188 to common scales.

each side of ocellar protuberance, which is black. Frons with trapezoid grey-brown mark anterior to ocellar protuberance, mark broader anteriorly; a grey-brown band between antennal socket and orbit. Antenna with scape pale brown, pedicel cream, f_1 pale brown, brown distally, flagellum otherwise brown with short cream bands at joints. Postclypeus with broad grey-brown band medially, anteclypeus cream, labrum brown. Apical segment of maxillary palp brown. Eyes black. Thoracic terga brown, cream arrow-shaped mark on mesothoracic pronotum, scutella pale, thoracic pleura brown. Legs: coxa brown basally, paling to cream; femur cream; tibia pale brown; tarsal segments darker. Fore wing (fig. 185) membrane very faint brown, paler basally, darker pigment confined to 3 large patches; areola postica veins extensively hyaline. Hind wing (fig. 186) hyaline. Abdomen with broad grey-brown transverse bands dorsally,





Figures 190–192. *Blaste lignicola*. Male: 190; epiproct, paraproct and ninth tergite; 191, hypandrium; 192, phallosome. Figures 190 and 192 to common scale.

ventrally cream; insect from side thus appears cream ventrally, pigmented dorsally.

Morphology. IO:D = 4.0. Epiproct (fig. 187) trapezoid with apical membranous lobe bearing a pair of long fine setae, at base of which is pair of sclerotised hooks. Paraproct (fig. 187) with circular field of 28 trichobothria and 1 seta without rosette. Subgenital plate (fig. 188) with heavily pigmented median band basal to apical lobe, band dividing anteriorly; sinuous band of setae extends from posterior edges of lateral sclerotised areas to anterior of plate. Gonapophyses (fig. 189).

Dimensions. B 2.9, FW 3.10, HW 2.36, F 0.75, T 1.38, t_1 0.395, t_2 0.134, rt 3.0:1, ct 14, 0, f_1 0.458, f_2 0.316.

Further description of male. Coloration (after ca 5 yr in alcohol). As female, but antenna wholly brown.

Morphology. IO:D = 3.8. Epiproct (fig. 190) with lateral anteriorly directed lobes covered with rounded papillae, a broad median finely papillose tract and a group of fine setae on posterior border medially. Paraproct (fig. 190) with oval field of 36 trichobothria. Hypandrium (fig. 191) with small rounded posterior lobe bearing about 5 setae on thickened margin, an adjacent sclerotised broad tooth, a small, finely granulated region with a group of about 9 setae immediately anterior to this tooth; lateral margins heavily sclerotised, a large laterally directed prominence on each side. Phallosome (fig. 192) as illustrated by New (1971).

Dimensions. B 2.6, FW 3.45, HW 2.68, F 0.69, T 1.40, t_1 0.403, t_2 0.111, rt 3.63:1, ct 23, 0, f_1 0.652, f_2 0.494.

Remarks. This species was collected from all vegetation types except bracken and closed forest.

Since Enderlein's original descripton of this species from material from Sydney, NSW, it has been recorded from Norfolk Island, Flinders, King and Curtis Islands in Bass Strait and Wilsons Promontory. *Blaste howicki* New, described from a single female found in a termite mound near Morwell, Victoria, before females had been found in association with males of *B. lignicola*, conforms in all respects to females found with males at Wilsons Promontory. The unusual fleshy spiculate mesial lobe of the outer valve mentioned and figured by New, is present also in the Wilsons Promontory specimens; the narrow posterior lobe, however, figured here (fig. 189), is folded in the set of gonapophyses figured by New, and present, although unsclerotised, on the right gonapophyses of his specimen (seen). The fore wing pigmentation of the Morwell specimen is faint.

There is an indication of variation in chaetotaxy of the female epiproct: medium-sized lateral setae vary in number from 6 to 9 on each side in the Wilsons Promontory material, the King Island female has 12 on each side and New's Morwell specimen 8 and 9.

Blaste taylori New

Blaste taylori New, 1974b: 286.

Material examined. 2♀, 1♂, 2 nymphs: site 6 (May 1985), site 8 (Jan 1991 – nymph only), site 29, site 41 (nymph only).

Remarks. This species, originally described from Western Australia, has since been recorded from NSW, Victoria and the Bass Strait islands.

Blaste tillyardi Smithers

Blaste tillyardi Smithers, 1969: 338.

Material examined. 1♀, 1♂: site 30, site 42.

Remarks. B. tillyardi is known from NSW and Victoria. It was originally described from New Zealand.

Clematostigma Enderlein

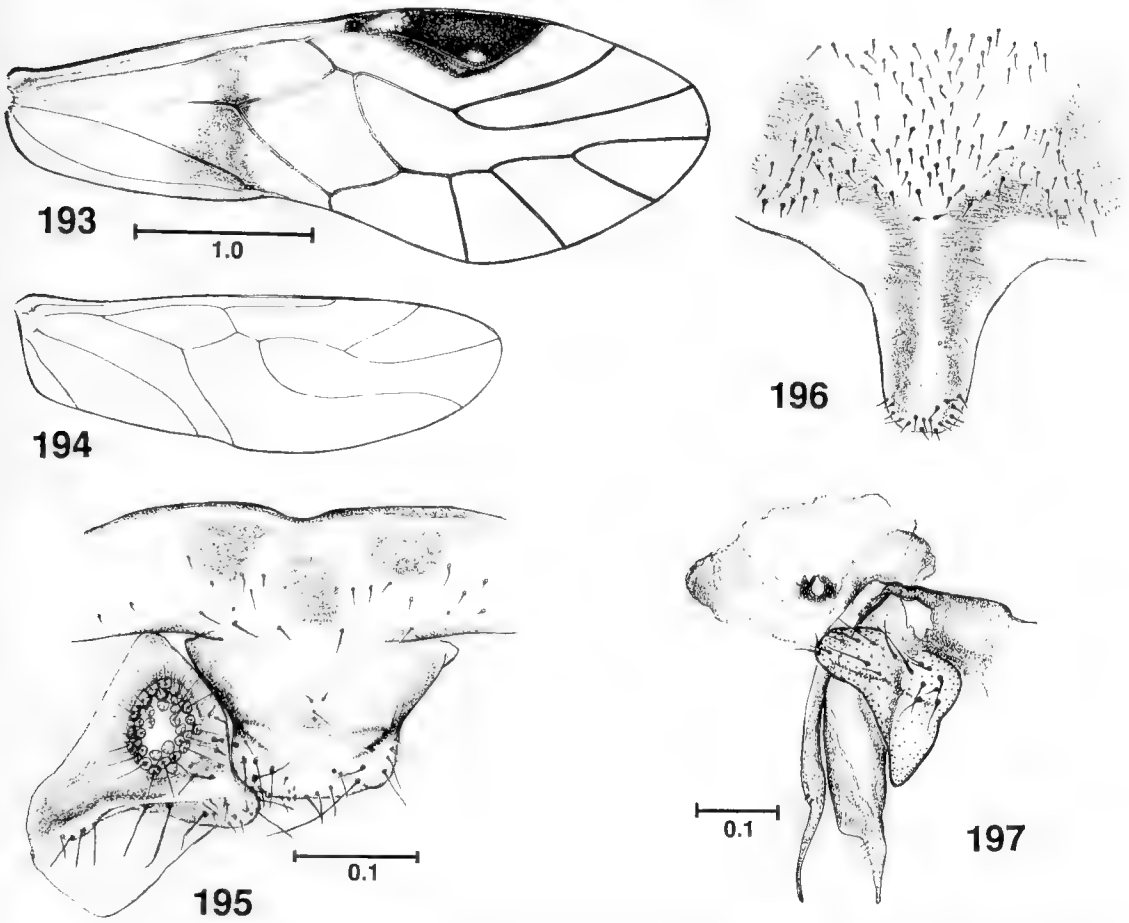
Clematostigma Enderlein, 1906: 403. Type species: *Copostigma maculiceps* Enderlein.

Clematostigma lunulata sp. nov.

Figures 193–201

Material examined. Holotype ♀: Cotters Lake, *Leptospermum lanigerum*, 18 Apr 1990; allotype ♂, 3♀ paratypes: same data as holotype (K73706–K73710). Additional records (10♀, 10♂): site 14 (Jan 1991), site 29, site 31, site 35, site 42, site 44.

Description of female. Coloration (after ca 6 mo in alcohol). General body color pale cream. Head with pattern of brown spots each side of epicranial suture, along posterior margin of head and mesad of orbits, the orbital patch not continuous with posterior pattern of pigmentation. Epicranial suture pale. Ocelli with black centripetal margins. A brown stirrup mark in centre of frons. Antennal socket ringed dark brown. Pale brown striae on postclypeus, anteclypeus pale, labrum dark brown. Apical segment of maxillary palp dark brown to black. Eyes black. Second flagellar segment pale brown darkening to brown distally, more distal segments brown, basal 3 antennal segments pale cream. Thoracic nota dark brown, contrasting with pale cream margins, mesothoracic antedorsum with pale cream median line, mesothoracic dorsal lobes with pale cream narrow wedge towards posterior of lobe, metathoracic dorsal lobes with pale cream oblong area towards posterior of lobe. Mesothoracic epimeron and postnotum, and metathoracic episternum brown; other sclerites on side of thorax pale cream. Legs pale cream with following exceptions: basal half of coxa, a broad subapical band on femur, a narrow sub-basal and apical ring on tibia and whole of tarsus dark brown. Fore wing (fig. 193) with wedge-shaped brown transverse fascia in basal half of wing not extending into costal cell, stigmasac dark brown, pterostigma with brown pigment and a hyaline window near vertex, the size of this window differs in the 2 wings. Veins in basal half of wing



Figures 193–197. *Clematostigma lunulata*. Female: 193, forewing; 194, hindwing; ;195, epiproct, paraproct and ninth tergite; 196, subgenital plate; 197, gonapophyses and spermathecal plate. Figures 193, 194 and 196 and 197 to common scales.

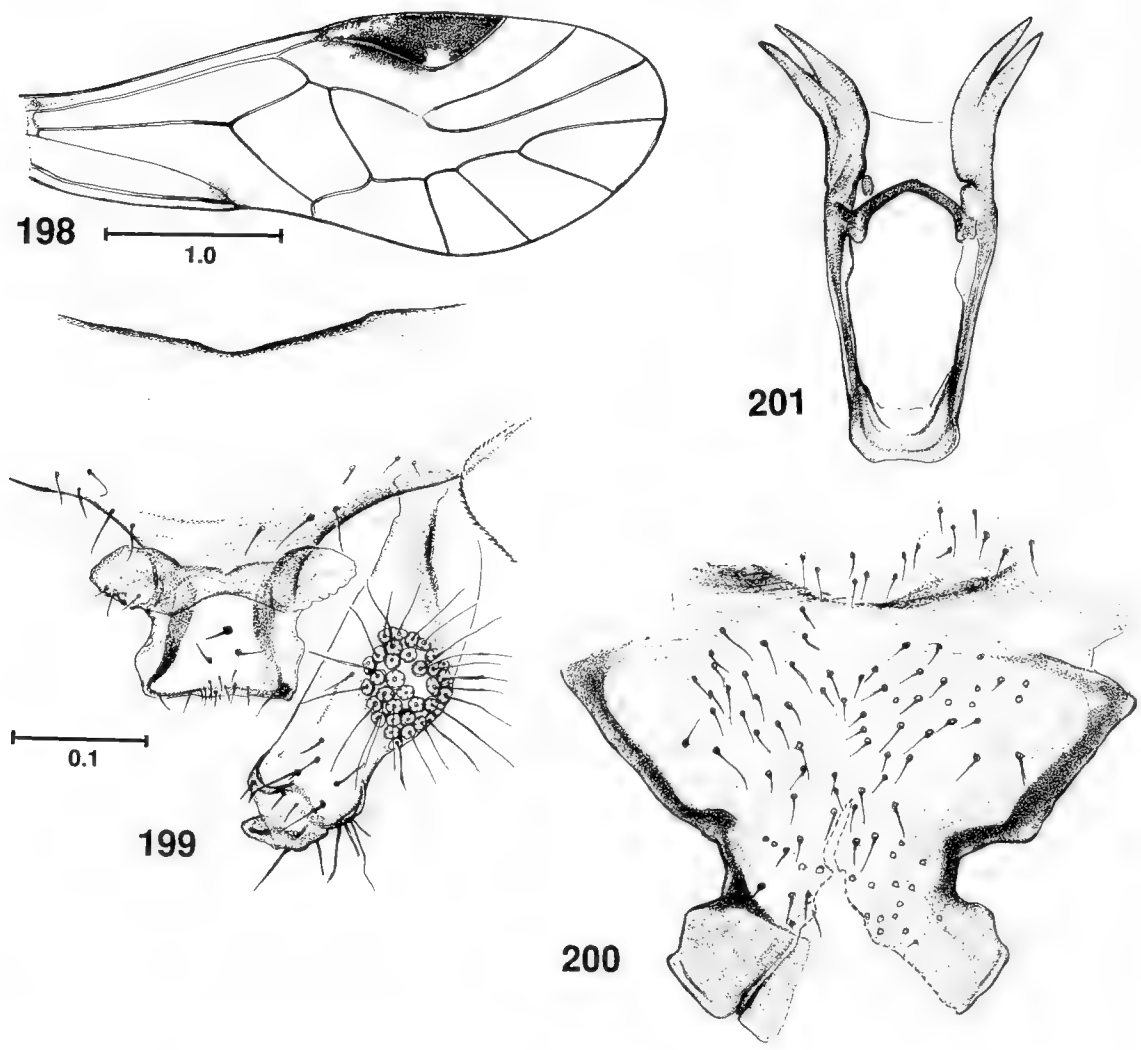
generally pale, those bounding areola postica, marginal medial cells and cell R_3 brown. Hind wing (fig. 194) with slight brown infuscation in cell R_3, apical angle of R_1, and apical third of anal cell; veins pale apart from apical sections of r_{2+3}, r_{4+5} and m and distal branch of vein $m+cu$ brown. Basal half of costal vein with hyaline and brown stretches. Abdomen cream with dark brown annulations.

Morphology. IO:D = 2.0. Claw with subapical tooth. No spurvein on pterostigma. First section of vein cu_{1a} longer than second but approximately in line with it. Epiproct (fig. 195) as in *Clematostigma maculiceps* but posterior transverse bars do not meet, 2 extremely long setae each side of posterior margin. Ninth abdominal tergite (fig. 195) with 3 raised reticulatedly sclerotised areas. Paraproct (fig. 195) with oval field of 30 trichobothria with bare area centrally. Subgenital plate (fig. 196) as in *C. maculiceps*. Gonapophyses (fig. 197): ventral and dorsal valves pointed, dorsal valve with a slight lobe some distance from apex; outer valve setose with tapering posterior lobe. Spermathecal plate (fig. 197) with heavily sclerotised ring.

Dimensions. B 2.9, FW 3.95, HW 2.74, F 0.67, T 1.38, t_1 0.292, t_2 0.166, rt 1.8:1, ct 18, 4, f_1 0.816, f_2 0.883.

Description of male. Coloration (after ca 6 mo in alcohol). As female except transverse fascia of fore wing (fig. 198) represented only by dark pigment in apical angle of cell Cu_2 and darkening of veins at distal end of vein $m+cu$; hyaline window at vertex of pterostigma larger.

Morphology. IO:D = 0.5. Posterior margin of ninth tergite (fig. 199) sclerotised and produced posteriorly as sclerotised base for epiproct. Epi-



Figures 198–201. *Clematostigma lunulata*. Male: 198, forewing; 199, epiproct and paraproct; 200, hypandrium; 201, phallosome. Figures 199–201 to common scale.

proct (fig. 199) with basal lateral lobes each bearing 8-9 small fine setae, a pair of heavily sclerotised skeletal rods diverging posteriorly to straight apical margin; 3 setae on surface of epiproct and a group of about 16 small setae along posterior margin concentrated medially. Paraproct (fig. 199) with circular field of about 40 trichobothria and an apical sharply pointed hook. Hypandrium (fig. 200) setose, posterior margin heavily sclerotised, posteriorly bilobed with anteriorly reflected flaps, the margins of which are also sclerotised. Phallosome (fig. 201) in general form similar to that of *C. maculiceps* but angular anteriorly and outwardly curved; outer parameres apically split, sharply pointed.

Dimensions. B 2.5, FW 3.69, HW 2.77, F 0.65, T 1.43, t_1 0.348, t_2 0.154, rt 2.3:1, ct 21, 4, f_1 0.960, f_2 1.018.

Remarks. This species appears to be confined to *Melaleuca* scrub and coastal vegetation.

C. lunulata is placed in *Clematostigma* Enderlein, as revised by Smithers (1983), in spite of the complete lack of a pterostigmal spur vein, because of its basic similarity, in features of male and female genitalia, to the type species, *C. maculiceps* (Enderlein), also found at Wilsons Promontory. The peculiar structure of the hypandrium and phallosome warrant this placement and therefore the presence of a spur vein on the pterostigma cannot be regarded as a gen-

eric character applying to all species (see key of Smithers, 1983: 79). It should also be noted that the first and second sections of vein cu_{1a} are almost in line. This feature together with the characteristic hyaline window near the vertex of the pterostigma easily distinguishes *C. lunulata* from *C. maculiceps.*

Clematostigma maculiceps (Enderlein)

Copostigma maculiceps Enderlein, 1903: 231.
Clematostigma maculiceps. — Enderlein, 1906: 403.

Material examined. 11♀, 1♂: site 39.

Remarks. Recently redescribed by Smithers (1983), the species was hitherto known from NSW (Sydney region) and Flinders Island, Bass Strait.

Clematostigma striata sp. nov.

Figures 202–207

Material examined. Holotype ♀: Millers Landing, shore vegetation, 21 Apr 1984 (K73711).

Description of female. Coloration (after ca 6 yr in alcohol). Body color generally pale cream. Posterior vertex with light brown markings extending anteriorly each side of epicranial suture and along edge of orbit. Epicranial suture dark brown. Ocelli pale with black centripetal borders, protuberance pale. From each posterior ocellus a curved grey-brown band slightly wider than diameter of ocellus extends along anterior of vertex towards anterior edge of orbit; from anterior ocellus each side a straight grey-brown band gradually widening laterally extends towards antennal socket; a similar grey-brown band along anterior border of frons surrounds antennal socket. Eyes black, gena unmarked. Apical segment of maxillary palp shading to dark grey-brown apically. Postclypeus with striae of distinct small brown spots leaving an unmarked hemispherical area anteriorly. Anteclypeus and labrum pale. Antenna pale (only 2 flagellar segments). Mesothoracic dorsa very dark brown anteriorly, metathoracic dorsa somewhat paler; side of thorax wholly pale except a narrow longitudinal grey-brown band above bases of coxae. Legs pale apart from a narrow subapical ring on tibia, and apex of t_1 and whole of t_2 grey-brown. Fore wing (fig. 202) with basal fascia not extending anterior to vein *m+cu.* Stigmasac brown, a grey-brown mark outside vertex of pterostigma and basal to spur vein, apex of pterostigma with a brown patch. Hind wing (fig. 203) with apical half of cell Cu_2 pale brown. Abdomen pale with granulated grey-brown markings.

Morphology. IO:D = 3.0. Mesothoracic pronotum highly polished. Pterostigma with distinct spur vein, first and second sections of veins cu_{1a} of fore wing in line. Claw with preapical tooth. Epiproct (fig. 204) rounded apically with 4 long setae on apical margin, broadly based with internal transverse sclerotised bars not meeting in midline. Paraproct (fig. 204) with a circular field of 30 trichobothria. Subgenital plate (fig. 205) with apical lobe elongate, broadening distally, a field of fine spicules near apical margin and a subapical field of 10 short setae; lobe with a pair of longitudinal sclerotised tracts, fusing at base of lobe as part of sclerotised area of disc, which is heavily setose. Gonapophyses (fig. 206): ventral valve elongate, acuminate; dorsal valve elongate, narrowing abruptly to short pointed apex; outer valve with very short conical posterior lobe. Spermathecal plate (fig. 207).

Dimensions. B 3.6, FW 4.51, HW 3.30, F 0.86, T 1.81, t_1 0.490, t_2 0.150, rt 3.3:1, ct 21, 3.

Male. Unknown.

Remarks. Based on a single female, the species is nevertheless clearly distinguishable from its Australian congeners. In female genitalia it resembles *C. maculiceps*, although the outer valve posterior lobe is much smaller. The gonapophyses of *C. striata* are more similar to *maculiceps* than are those of *C. lunulata*, although the latter's subgenital plate is closer to the type species. *C. striata* has a pterostigma spur vein (in contrast to *C. lunulata*), but the shape of the areola postica is more similar to *C. lunulata* than it is to *C. maculiceps.* This species can be distinguished from *lunulata* and *maculiceps* by the three dark parallel lines between the ocellar protuberance and the clypeus, and by the shape of the transverse fascia of the fore wing, which is very broad in cell Cu_2, narrow in cell Cu_1, and entirely absent anterior of vein *m+cu.* It is also distinctive in the pattern of pigmentation of the sides of the thorax and of the legs.

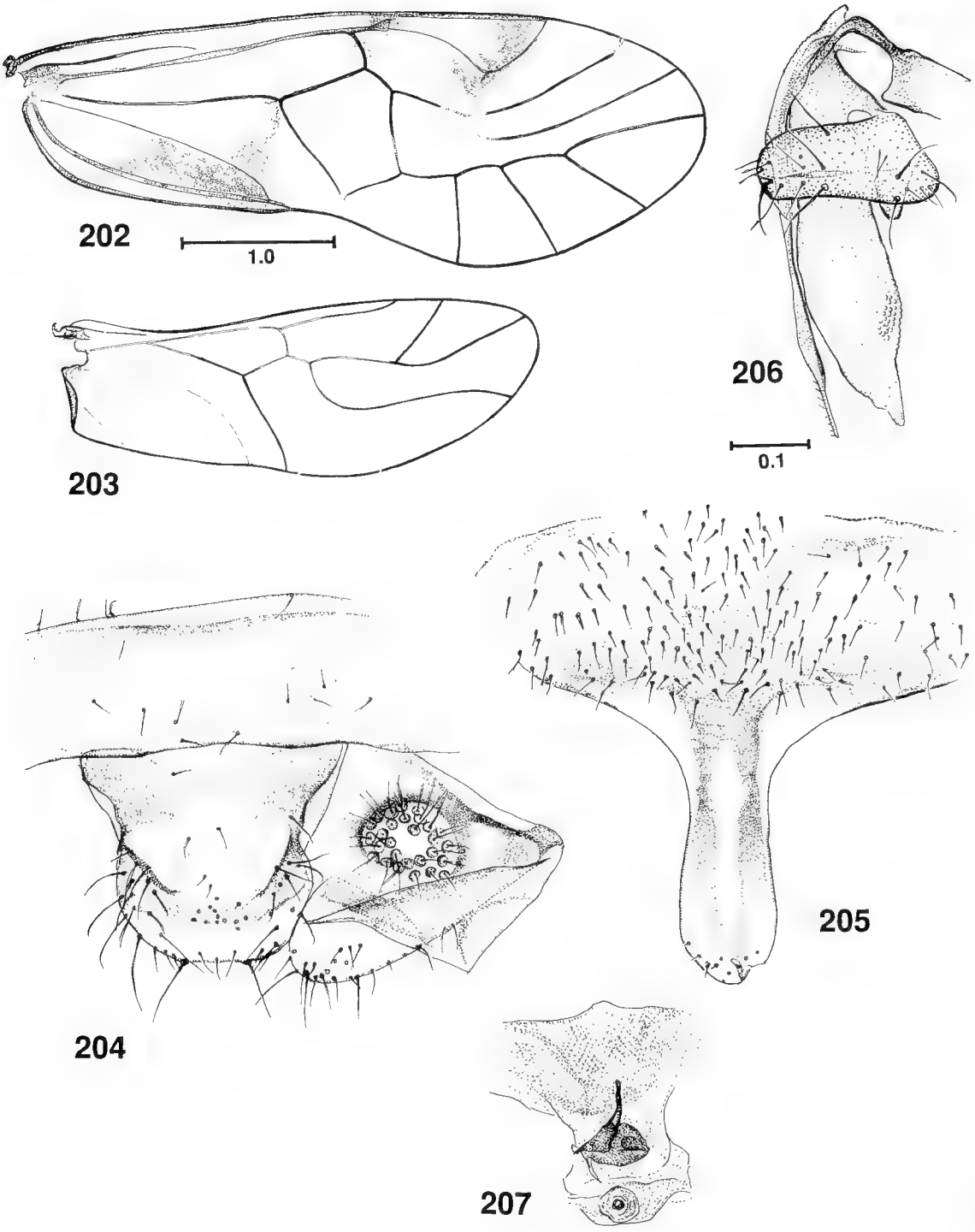
Ptycta Enderlein

Ptycta Enderlein, 1925: 102. Type species: *Psocus haleakalae* Perkins.

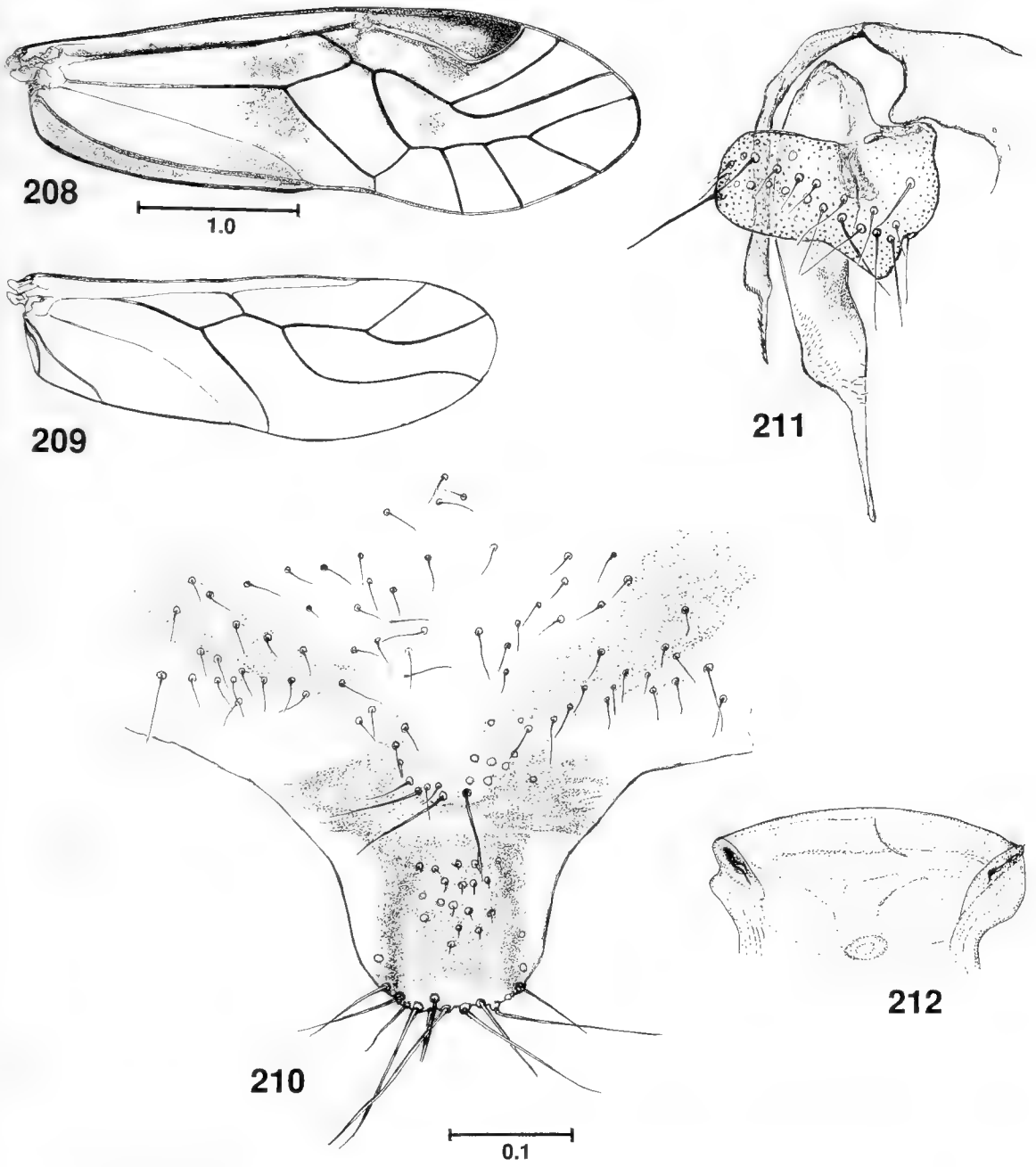
Ptycta australis sp. nov.

Figures 208–217

Material examined. Holotype ♀: Darby Beach Track, coastal dune vegetation, 29 Sep–1 Oct 1985; allotype ♂, Lilly Pilly Nature Track, closed heath, 15–16 Dec



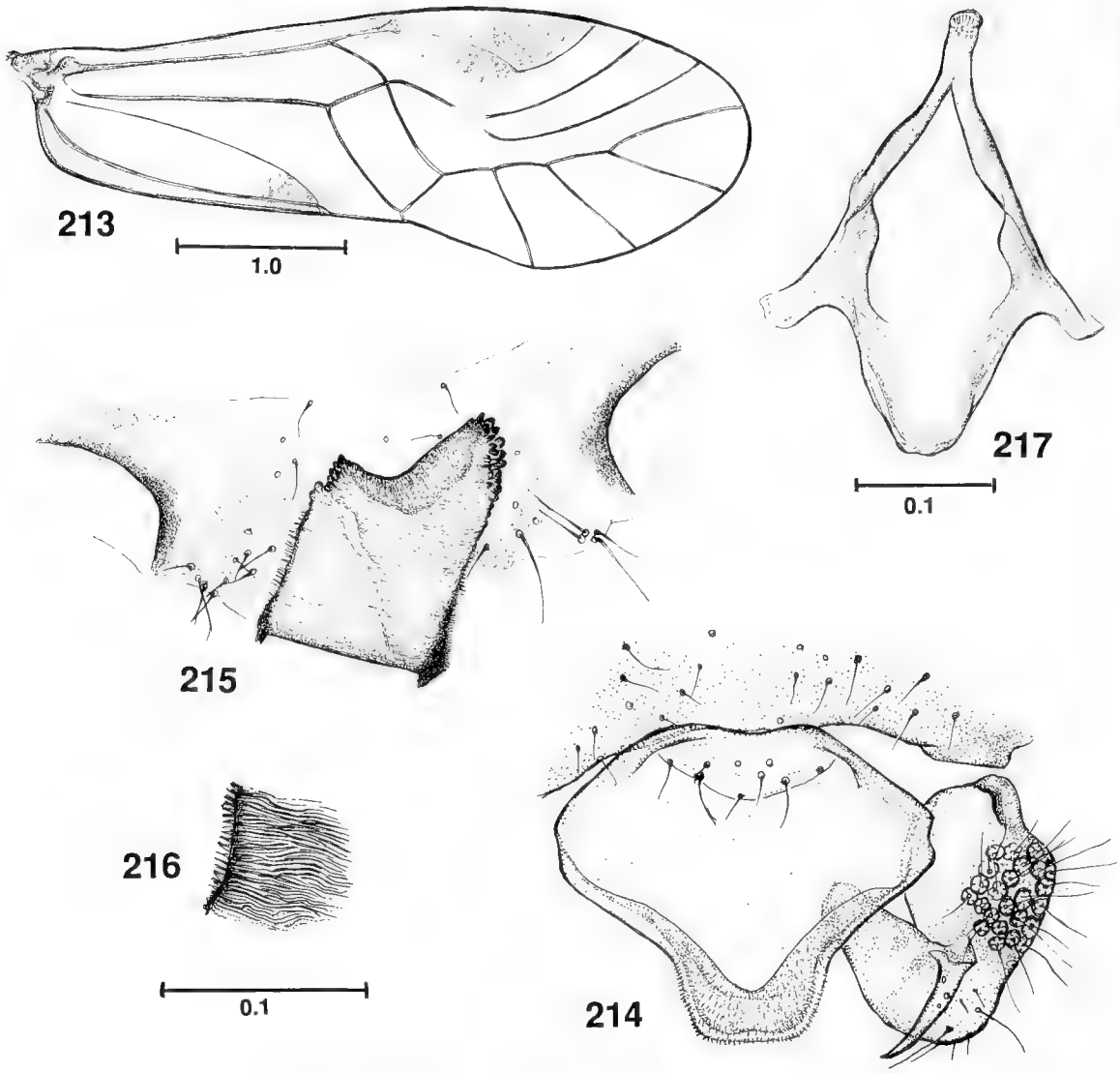
Figures 202–207. *Clematostigma striata*. Female: 202, forewing; 203, hindwing; 204, epiproct and paraproct; 205, subgenital plate; 206, gonapophyses; 207, spermathecal plate. Figures 202, 203 and 204–207 to common scales.



Figures 208–212. *Ptycta australis*. Female: 208, forewing; 209, hindwing; 210, subgenital plate; 211, gonapophyses; 212, spermathecal plate. Figures 208, 209 and 210–212 to common scales.

1985; 4 nymphs, 2♀ paratypes: same locality as allotype, 20–21 Nov 1985 (K73712–K73715). Specimen on which fig. 214 of male epiproct based: Mt William National Park, north-east Tasmania, heath, 7 Dec 1986. Additional records (17♀, 9♂, 6 nymphs): site 4 (May 1985), site 14 (Apr 1990), site 20, site 36, site 41, site 42.

Description of female. Coloration (after ca 5 yr in alcohol). Ground color of head, cream; small adjacent dark brown markings on vertex dorsal to eyes, across posterior and beside epicranial suture. Eyes dark grey. Ocelli with centripetal edges bordered black. Gena with row of 3 or 4 brown patches below orbit. Scape and pedicel cream, flagellum brown. Frons with brown stirrup mark anterior to ocelli and brown spot half



Figures 213–217. *Ptycta australis*. Male: 213, forewing; 214, epiproct and paraproct of Tasmanian specimen; 215, hypandrium; 216, surface of tongue of hypandrium; 217, phallosome. Figures 214, 215 and 217 to common scale.

way between this and antennal socket. Fronsclypeal suture black. Postclypeal striae grey. Apical segment of maxillary palp pale buff, extreme apex dark brown. Antedorsum and dorsa of mesothorax cream, posterior margins of antedorsum and mesad margins of dorsa narrowly bordered brown, dorsa of metathorax brown, thoracic pleura brown. Legs cream except: coxa brown, femur with brown ring basally and subapically, tibia dark brown at extreme apex, basal tarsal segment brown, apical segment darker. Fore wing with brown pigment as fig. 208. Hind wing (fig. 209) hyaline with brown cloud in distal angle of cell Cu_2. Abdomen dorsally with broad grey-brown annulations.

Morphology. IO:D = 3.0. Eyes offstanding posteriorly. Epiproct very similar to *Ptycta hollowayae* Smithers, with 2 very long setae near each posterior corner and row of 5 setae along posterior margin. Paraproct with circular field of 22 trichobothria. Subgenital plate (fig. 210). Gonapophyses (fig. 211). Sclerotisation of spermathecal plate (fig. 212).

Dimensions. B 3.0, FW 3.30, HW 2.57, F 0.68,

T 1.45, t_1 0.391, t_2 0.197, rt 2.0:1, ct 19, 0, f_1 0.671, f_2 0.585.

Description of male. Coloration (after ca 5 yr in alcohol). As female with following exceptions: basal flagellar segment and basal three-quarters of f_2 as rest of flagellum; fore wing (fig. 213) with less extensive brown clouds, no trace of transverse fascia. Hind wing hyaline.

Morphology. IO:D = 3.8. Epiproct (fig. 214 – from Tasmanian specimen, anterior margin facing posterior direction) similar to that of *Ptycta hollowayae*, but ratio of greatest width of epiproct to width of basal lobe greater. Paraproct (fig. 214) with large terminal spine, 4 setae over middle third of outer edge sited on sclerotised marginal low prominences giving margin of spine a slightly serrate appearance from some angles; circular field of about 33 trichobothria. Hypandrium (fig. 215, folded) with strap-like tongue bearing row of fine pointed teeth along margin, these becoming broader, with more rounded apex, and in double row towards distal end of tongue; apex of tongue asymmetrically curled; surface of tongue rugose, with close-set anastomising sinuous microscopic transverse ridges (fig. 216); each side of tongue a sclerotised curved bar protruding from surface of sclerite as a low point. Phallosome (fig. 217).

Dimensions. B 2.7, FW 3.91, HW 3.07, F 0.71, T 1.56, t_1 0.466, t_2 0.201, rt 2.3:1, ct 24, 4, f_1 0.845, f_2 0.691.

Remarks. Predominantly found in *Melaleuca* scrub and heath at Wilsons Promontory, *Ptycta australis* differs from its close congeners *Ptycta glossoptera* New and *P. hollowayae* in the extensive pigmentation of the female fore wing. *P. hollowayae*'s fore wing has pigmentation only in the anal cell as a broken transverse fascia, and brown clouds associated with the pterostigma. Fore wings of *P. glossoptera* and *P. australis* have, in addition, pigmented clouds associated with veins *m*, *rs*, and the section of vein *r* immediately basal to its fusion with *m*; in both these species also there is a brown cloud in cell R_5 between the junction of the radial fork and the areola postica. *P. australis* differs from *P. glossoptera* in that the clouds on the *media* and in cell R_5 are absent in the male fore wing, and the broken transverse fascia is broader and more extensively pigmented in the female. The outer valve of the female gonapophyses of *P. australis* has a short triangular posterior lobe intermediate in size between those illustrated for the other two species. The sclerotisation of the ninth sternite of the female differs in details from that of *P. hollowayae*. *P. australis* is also, in general, smaller than the other two species.

Ptycta campbelli sp. nov.

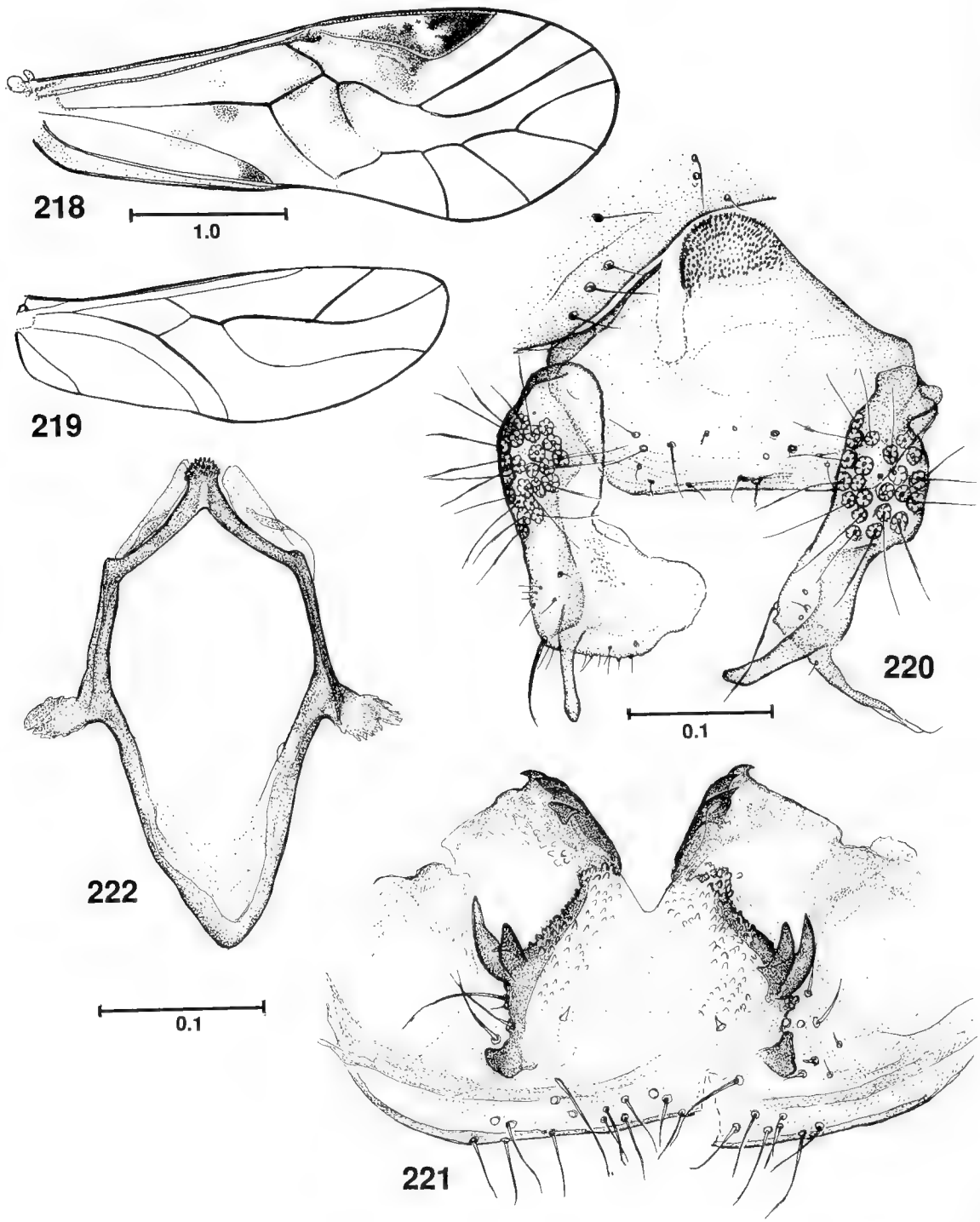
Figures 218–226

Material examined. Holotype ♂: Darby Beach Track, coastal dune vegetation, 12–14 May 1985; allotype ♀: Telegraph Saddle, low eucalypt woodland, 22–25 Jan 1985; 5 nymphs, 2♀ and 1♂ paratypes: holotype locality, 20–21 Nov 1985 (K73716–K73720). Additional records (83♀, 21♂, 48 nymphs): site 2 (Mar, Apr, Nov, Dec 1985, Jan, Feb 1986), site 3 (Jan, Feb 1985), site 4 (Nov 1985, Jan, Feb 1986), site 5 (Dec 1985), site 6 (Mar 1985), site 9 (Mar, Apr, Nov, Dec 1985, Jan, Feb 1986), site 10 (Apr, May, Nov, Dec 1985, Jan, Feb 1986), site 11 (Nov 1985, Feb 1986), site 12, site 13, site 15 (Apr 1984, Jan 1985), site 16, site 20, site 21, site 22, site 23, site 24, site 25, site 26, site 37, site 40, site 42, site 43, site 44.

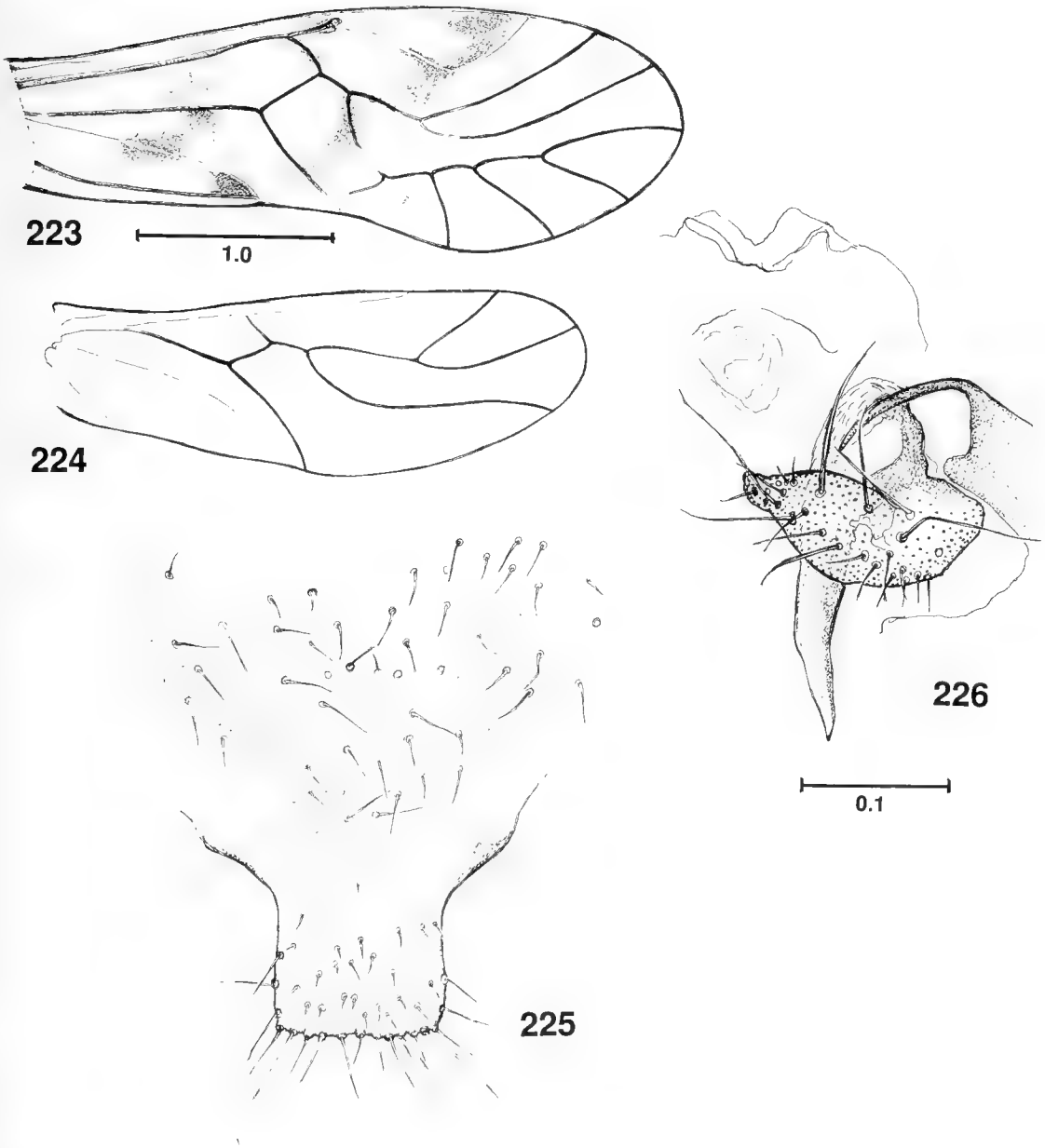
Description of male. Coloration (after ca 5 yr in alcohol). Head cream with dark brown markings as follows: patches behind eyes, along posterior of vertex, each side of epicranial suture and mesad of orbits. Median epicranial suture black. Ocellar protuberance brown, ocelli with black marginal pigment, a brown spot each side of protuberance. Eyes black. Vertex-frons suture broadly margined brown, a median brown stirrup mark on vertex and brown pigment covering each lateral quarter of vertex. Gena with curved brown mark below orbit. Clypeal striae distinct. Labrum brown. Maxillary palp apical segment dark brown. Scape and pedicel brown, f_1 brown darkening distally, rest of flagellum dark brown. Mesothoracic pronotum and anterior half of dorsal lobes pale brown, posteriorly dorsal lobes brown; a dark brown mesial suture on mesothorax widely bordered cream, scutellum pale; metathoracic dorsal lobes brown; thoracic pleura brown. Legs cream except coxa, apex of tibia and tarsal segments brown, femur with subapical brown band. Fore wing (fig. 218) with brown markings; hind wing (fig. 219) hyaline. Abdomen with grey-brown granular markings forming indistinct annuli.

Morphology. IO:D = 3.7. Epiproct (fig. 220) with finely spinous anterior lobe. Paraproct (fig. 220) with oval field of 27 trichobothria. Hypandrium (fig. 221): median tongue with row of 4 large curved spines each side, a tract of fine spinelets with a pair of very large spines towards base of tract, a large squat blunt spine at base each side. Phallosome (fig. 222) less heavily sclerotised apically.

Dimensions. B 2.4, FW 3.73, HW 2.76, F 0.664, T 1.534, t_1 0.458, t_2 0.134, rt 3.42:1, ct 23, 3, f_1 0.798 f_2 0.735.



Figures 218–222. *Ptycta campbelli*. Male: 218, forewing; 219, hindwing; 220, epiproct and paraprocts; 221, hypandrium; 222, phallosome. Figures 218, 219 and 221 and 222 to common scales.



Figures 223–226. *Ptycta campbelli*. Female: 223, forewing; 224, hindwing; 225, subgenital plate; 226, gonapophyses and spermathecal plate. Figures 223, 224 and 225 and 226 to common scales.

Description of female. Coloration (after ca 5 yr in alcohol). Head as male except frons with brown spot anterolaterally and another at anterolateral angle. Clypeus with semi-circular paler area each side anteriorly. Fore wing (fig. 223) patterned very much as male, pterostigma less extensively pigmented. Hind wing (fig. 224).

Morphology. IO:D = 4.6. Epiproct setose. Paraproct with circular field of 26 trichobothria. Subgenital plate (fig. 225) with Y-shaped pattern of sclerotisation, a line of long and medium length setae on posterior margin and posterior quarter of lateral margin of apical lobe; scattered short setae on apical lobe. Gonapophyses (fig. 226): ventral valve short, membranous; dorsal valve with sclerotised and membranous

portions, outer valve spindle-shaped, covered with very long setae. Spermapore plate (fig. 226) with complex pattern of sclerotisation.

Dimensions. B 3.0, FW 3.69, HW 2.83, F 0.678, T 1.445, t_1 0.395, t_2 0.150, rt 2.63:1, ct 24, 3, f_1 0.711, f_2 0.671.

Etymology. This species is named after Scott Campbell, Head Ranger of Wilsons Promontory National Park, for his assistance with this project.

Remarks. Characteristics of wing pattern and the hypandrium are distinctive. The species occurs in almost all vegetation types at Wilsons Promontory (it was not taken in mangroves).

Ptycta glossoptera New

Ptycta glossoptera New, 1974b: 302.

Material examined. 33♀, 12♂, 29 nymphs: site 1 (Jul, Dec 1985), site 3 (Mar 1985, Jan, Feb 1986), site 4 (Nov 1985), site 10 (Jan 1985, Feb 1986 — nymph only), site 14 (Apr 1984, Apr 1990, Jan 1991), site 15 (Jan 1985), site 20, site 22, site 23, site 29, site 32, site 36, site 42.

Remarks. This species, predominantly found in heath, scrub and coastal vegetation, was originally described from Wilsons Promontory. It has also been recorded from South Australia and the Bass Strait islands.

Ptycta muogamarra Smithers

Ptycta muogamarra Smithers, 1977: 288.

Material examined. 2♀, 1♂: site 42.

Remarks. This is the first record of the species since it was described from Muogamarra, near Sydney, NSW. Found here in closed scrub (on *Kunzea ambigua*).

Ptycta prosta sp. nov.

Figures 227–232

Material examined. Holotype ♀: Lilly Pilly Nature Track, closed heath, 15–16 Dec 1985 (K73721).

Description of female. Coloration (after ca 5 yr in alcohol). General body color pale buff. Vertex with sparse but distinct brown spots dorsal to each eye, across posterior of vertex, and flanking pale epicranial suture. Ocellar protuberance pale, ocelli pale, centripetally margined black. Eyes black. From anterior ocellus a brown V extends to dark brown frons-clypeal suture. Gena unmarked. Apical segment of maxillary palp brown in apical third. Antenna: scape, pedicel, f_1 and basal four-fifths of f_2 very pale buff, remainder of flagellum brown. Postclypeus with very narrow striae, 3 small brown spots in line just anterior to frons-clypeal suture each side mesad of antennal socket. Anteclypeus and labrum pale. Antedorsum and mesothorax pale buff, dorsal lobes very pale except posteriorly and mesially margined brown; metathoracic dorsa brown, each with a central pale buff spot; sides of thorax pale apart from mesothoracic epimeron and postnotum and metathoracic episternum brown. Legs pale buff apart from basal two-thirds of coxa, a mark on basal fifth of femur, a subapical brown ring on femur, apex of tibia and whole of tarsus brown. Fore wing (fig. 227) with interrupted transverse fascia and distinctive brown markings. Hind wing (fig. 228) hyaline apart from a light brown cloud over apex of cell Cu_2. Abdomen with distinct grey-brown annulations, these broadening and fusing along midline dorsally.

Morphology. IO:D = 4.0. Eyes offstanding posterior margin of vertex. No spur vein on pterostigma. Epiproct (fig. 229). Paraproct (fig. 230) with oval field of 21 trichobothria. Subgenital plate (fig. 231). Gonapophyses (fig. 232) with ventral valve broad basally, narrow in basal third, short; dorsal valve rather narrow; outer valve without posterior lobe.

Dimensions. B 3.2, FW 3.33, HW 2.57, F 0.66, T 1.43, t_1 0.371, t_2 0.197, rt 1.9:1, ct 17, 3, f_1 0.691, f_2 0.592.

Male. Unknown.

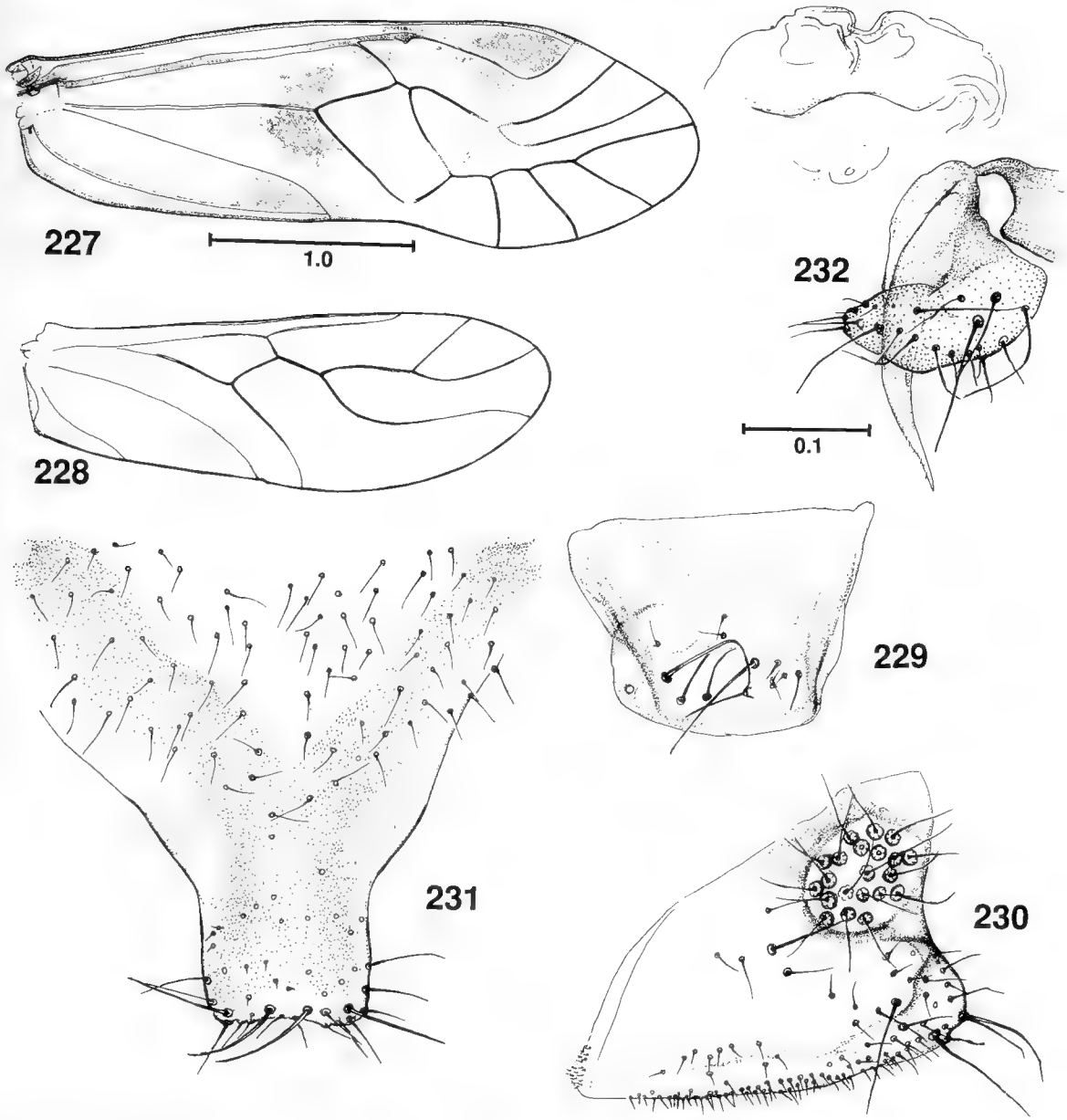
Remarks. Based on a single female, the fore wing pattern is distinctive. In general pattern of female fore wing *P. prosta* resembles females of *P. glossoptera* and *P. australis*, also found at Wilsons Promontory. It differs from both, however, in the pattern of pigmentation in the anal cell; in contrast to these two species, in *P. prosta* the anal cell is pale basally, darkest midway and light brown apically. A very short ventral valve is also found in *Ptycta emarginata* New (WA), *Ptycta umbrata* New (below, also occurring at Wilsons Promontory) and *P. campbelli* (above, also occurring at Wilsons Promontory), but all these species are distinct from *P. prosta* on wing pattern.

Ptycta umbrata New

Ptycta umbrata New, 1974b: 297.

Material examined. 2♀, 5♂, 12 nymphs: site 1 (May 1985, Feb 1986), site 18.

Remarks. This species, found on *Casuarina stricta* and *Banksia integrifolia*, has been recorded from Victoria and South Australia.



Figures 227–232. *Ptycta prosta*. Female: 227, forewing; 228, hindwing; 229, epiproct; 230, paraproct; 231, subgenital plate; 232, gonapophyses and spermathecal plate. Figures 227, 228 and 229–232 to common scales.

Sigmatoneura Enderlein

Sigmatoneura Enderlein, 1908: 761. Type species: *Cerastipsocus subcostalis* Enderlein.

Sigmatoneura formosa (Banks)

Amphigerontia formosa Banks, 1918: 4.
Loensia formosa. — Enderlein, 1924: 35.
Sigmatoneura formosa. — Smithers, 1976: 72.

Material examined. 2♀, 2♂: site 44.

Remarks. Redescribed by Smithers (1976), this species was hitherto known from north Queensland and NSW. It was found here on *Leptospermum laevigatum.*

Tanystigma Smithers

Tanystigma Smithers, 1983: 77. Type species: *Copostigma (Clematostigma) paula* Smithers.

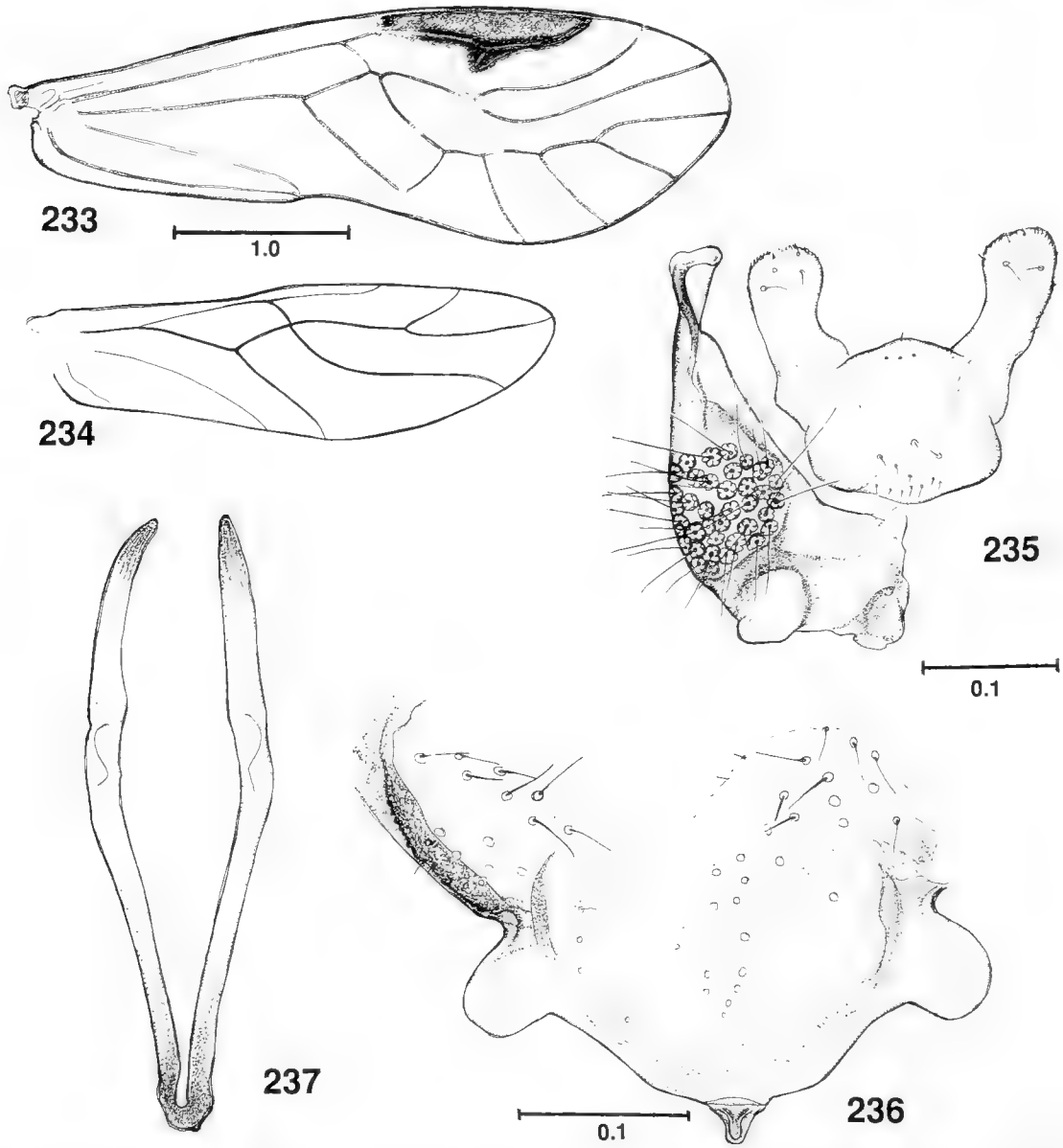
Tanystigma inglewoodense (New)

Figures 233–237

Clematostigma inglewoodense New, 1974b: 296.
Tanystigma inglewoodense. — Smithers, 1983: 77.

Material examined. Specimen on which description based: ♂, Telegraph Saddle, low eucalypt woodland, 12–14 May 1985. Additional records (50♀, 31♂, 37 nymphs): site 2 (Sep, Oct 1985), site 3 (Nov 1985 – nymph only, Jan 1986), site 4 (Apr, May, Nov – nymph only, Dec 1985, Jan 1986), site 5 (Apr 1985), site 10 (Dec 1985), site 12, site 14 (Apr 1984, Apr 1990, Jan 1991), site 20, site 23, site 24, site 27, site 29, site 30, site 31, site 32, site 35, site 36, site 37, site 41, site 42.

Description of male. Coloration (after ca 5 yr in alcohol). As female description (New, 1974b) except: frons with brown stirrup mark anterior to ocelli; a grey-brown streak along posterior suture; clypeus with triangular dark grey-brown



Figures 233–237. *Tanystigma inglewoodense.* Male: 233, forewing; 234, hindwing; 235, epiproct and paraproct; 236, hypandrium; 237, phallosome. Figures 233, 234 and 235 and 237 to common scales.

mark mesad of antennal socket; thoracic terga brown (these differences are also apparent in females of our collection, except the frontal streak is narrower than in the male, and the dark band on femur is subapical, not apical in both sexes). Fore wing (fig. 233) without transverse fascia. Hind wing fig. 234.

Morphology. IO:D = 4.5 Pterostigma more elongate than in female, spur vein half way along its length. Epiproct (fig. 235) with row of 4 subapical setae, membraneous, with long anterior lateral lobes bearing scattered setae. Paraproct (fig. 235) with rounded field of 35 trichobothria. Hypandrium (fig. 236) with apical sclerotised peg, a pair of lateral rounded lobes, margin basal to lobes heavily sclerotised. Phallosome (fig. 237) with parameres anteriorly joined, apically pointed and apparently jointed one-third length from apex.

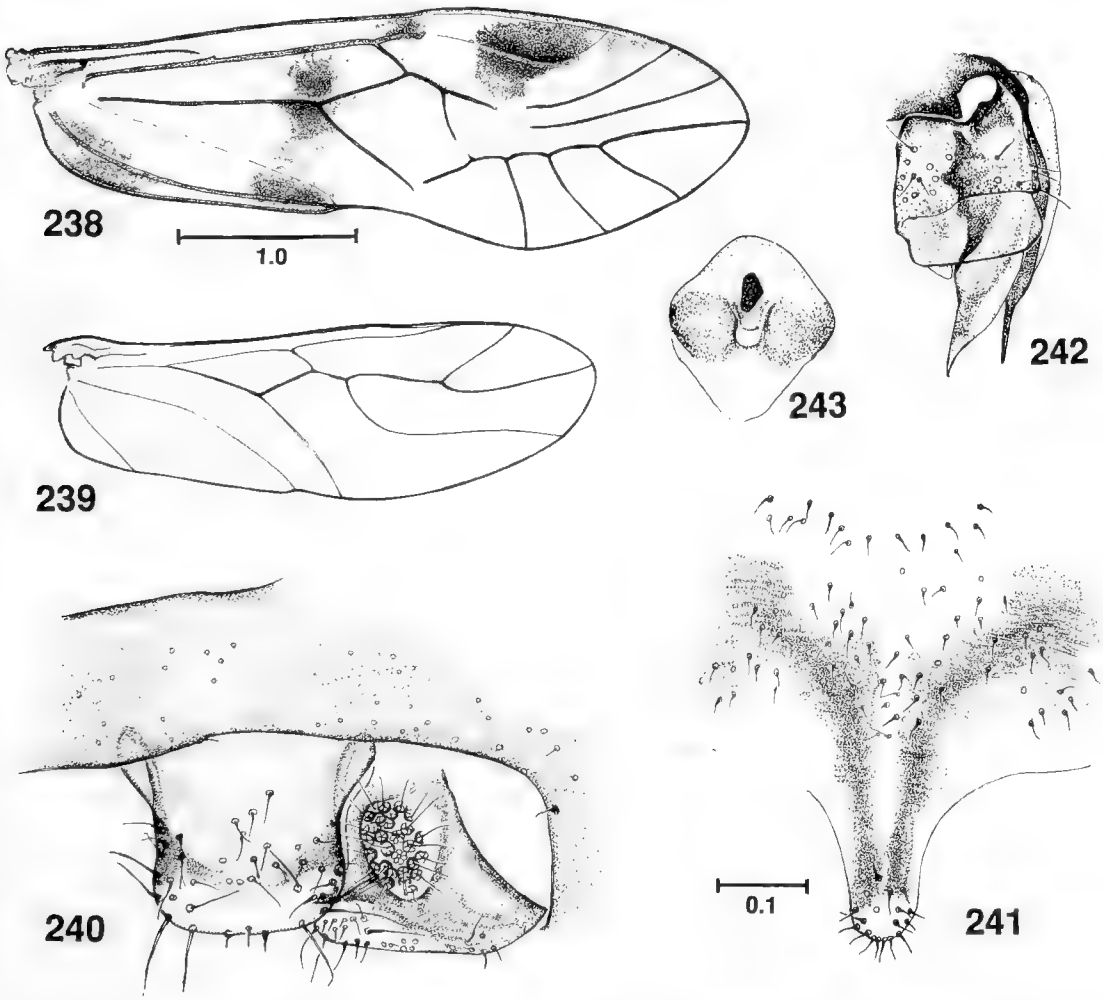
Dimensions. B 2.6, FW 4.06, HW 3.04, F 0.63, T 1.33, t_1 0.379, t_2 0.213, rt 1.8:1, ct 19, 3, f_1 0.902, f_2 0.864.

Remarks. Apart from low eucalypt woodland, the species was collected only in heath and scrub vegetation. Wilsons Promontory is the second locality known for this species, described from a single female near Inglewood, Victoria.

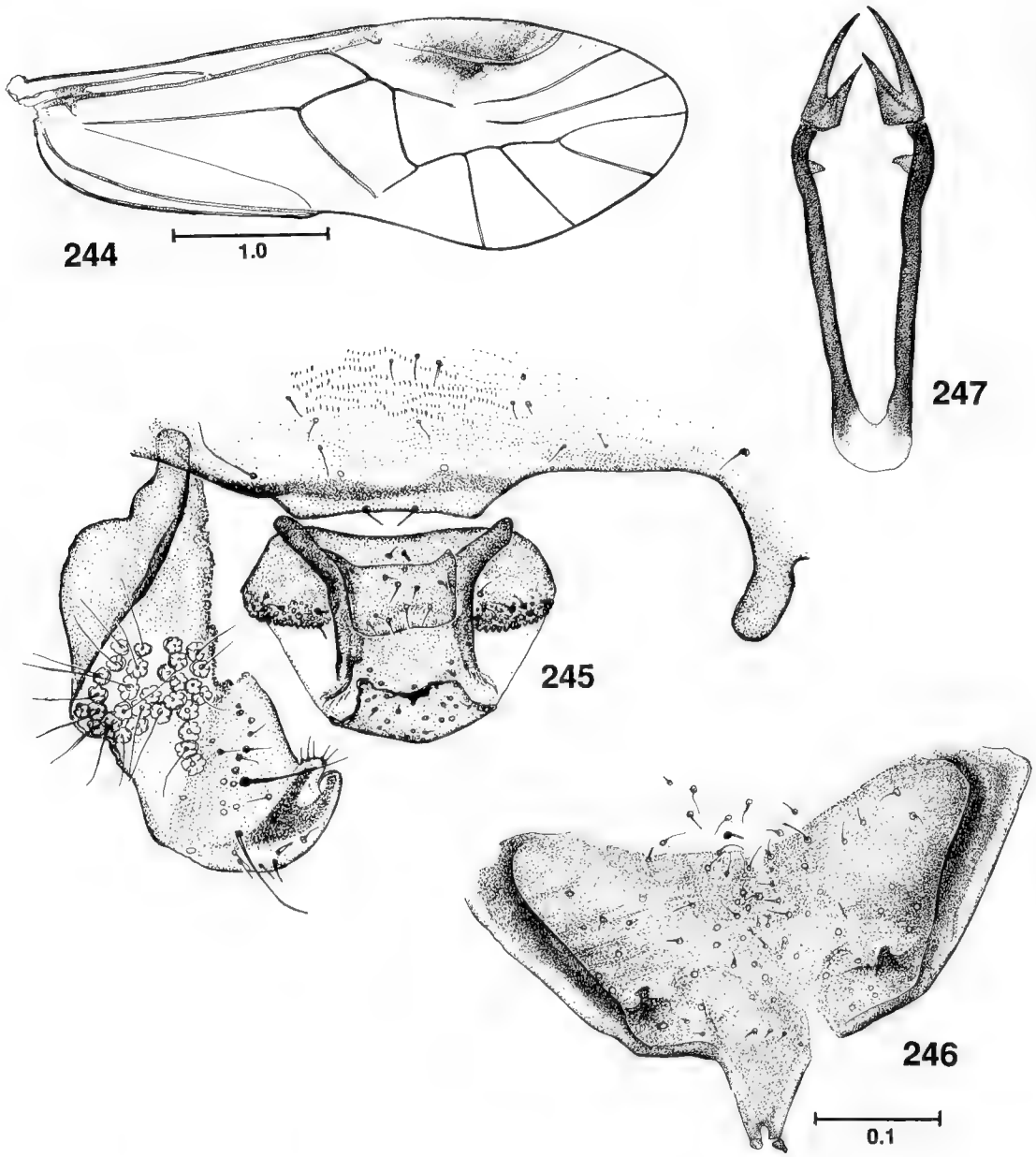
Tanystigma valvula sp. nov.

Figures 238–247

Material examined. Holotype ♀: Lighthouse Walking Track, about 2 km east of Roaring Meg camping area, closed heath, 26 Apr 1989; allotype ♂: same data as



Figures 238–243. *Tanystigma valvula*. Female: 238, forewing; 239, hindwing; 240, epiproct and paraproct; 241, subgenital plate; 242, gonapophyses; 243, spermathecal plate. Figures 238, 239 and 240–243 to common scales.



Figures 244–247. *Tanystigma valvula*. Male: 244, forewing; 245, epiproct, paraproct and ninth tergite; 246, hypandrium; 247, phallosome. Figures 245–247 to common scales.

holotype (K73722, K73723). Additional records (1♀): site 37.

Description of female. Coloration (after ca 1 yr in alcohol). Ground color of head creamy-white with dark brown markings as follows: small merging patches each side of epicranial suture, along posterior of vertex and mesad of orbit; gena with very small dark patches immediately below orbit. Antenna brown. Ocellar protuberance dark brown. Postclypeus with 10 longitudinal striae and 3 short striae angled at margins, anteclypeus and labrum black. Penultimate segment of maxillary palp brown, apical segment black. Eyes black. Mesothoracic terga black, a small cream median line. Metathoracic terga

black with a smaller median cream line anteriorly. Pleura dark brown-black. Fore wing (fig. 238) with a distinct broken transverse fascia and a cloudiness in cell R_1 near wing margin. Hind wing (fig. 239) hyaline, very faint cloud at apical angle of cell Cu_2. Hind leg with coxa, femur and tarsal segments very dark brown, tibia buff, dark brown apically. Abdomen cream with granulated greyish pigment dorsally.

Morphology. IO:D = 3.2. Basal section of vein cu_{1a} of fore wing (fig. 238) longer than apical section, but the 2 almost in line. Epiproct (fig. 240) heavily sclerotised marginally. Paraproct (fig. 240) with oval field of 33 trichobothria. Subgenital plate (fig. 241) with distal area of apical lobe setose and membraneous. Gonapophyses (fig. 242) with massive outer valve having rectangular apical lobe as large as rest of valve. Spermapore plate (fig. 243) of distinctive shape and pattern of sclerotisation.

Dimensions. B 3.8, FW 4.09, HW 3.10, F 0.74, T 1.55, t_1 0.340, t_2 0.174, rt 2.6:1, ct 15, 4, f_1 0.743, f_2 0.569.

Description of male. Coloration (after ca 1 yr in alcohol). As female except fore wing pigment confined to areola postica and outer margin of cell R_1.

Morphology. IO:D = 1.2. Fore wing (fig. 244) as female but sections of cu_{1a} equal in length. Epiproct (fig. 245) with rectangular basal setose flap and lateral ovoid rugose lobes bearing scattered setae. Ninth tergite with ventrolateral apophyses (fig. 245), hind margin thickened anterior to epiproct. Paraproct (fig. 245) with distinct curved skeletal bar, oval field of 31 trichobothria and sclerotised double claw apically. Hypandrium (fig. 246) apically bifid, terminating in a pair of short, broad pointed spines; on body of hypandrium near posterior lateral angle each side a broad short hook directed anterolaterally. Phallosome (fig. 247) closed anteriorly, but junction not sclerotised, posteriorly open with a pair of double, sharp sclerotised spines.

Dimensions. B 3.5, FW 4.19, HW 3.13, F 0.74, T 1.64, t_1 0.434, t_2 0.190, rt 2.3:1, ct 18, 6, f_1 0.727, f_2 0.600.

Remarks. In several features this species appears to be related to *Tanystigma notialis* (Smithers) from Western Australia. The pair of rounded lateral lobes on the male epiproct, the inwardly pointing bifid spines of the phallosome and the membraneous apex of the subgenital plate are similar in the two species. In both species also the outer valve of the female gonapophyses is very large. *T. valvula* differs from *T. notialis* in the pigmentation of the fore wing, the restriction of setae to the distal portion of the apical lobe of the subgenital plate, the straight posterior border of the outer valve (sinuous in *T. notialis*) and the bifid hooks of the phallosome (longer than in the Western Australian species). The female is remarkably similar to *Tanystigma bifurcata* Smithers from South Australia in the form of the subgenital plate, the outer valve of the gonapophyses and the pattern of pigment of the fore wing. The male, which like that of *T. bifurcata* (and *T. notialis*) has bifid spines at the apex of the phallosome and (not mentioned in *T. notialis*) ventrolateral apophyses on the ninth tergite, differs however from *T. bifurcata* in details of the structure of the phallosome, epiproct and hypandrium. The hooks on each side of the hypandrium at the posterior angles are similar in form and position to those of *Lasiopsocus dicellus* Smithers. The female is also similar to *Tanystigma dubium* (New) (males unknown) from Victoria and Western Australia in the form of the subgenital plate and the outer valve of the gonapophyses. *T. dubium* differs however in the pigmentation of the pterostigma of the fore wing and in lacking the small dorsal lobe of the outer valve of the gonapophyses.

Species known to have single-spined phallosomes [*Tanystigma paula* (Smithers), *Tanystigma latimentula* (Smithers), *Tanystigma elongata* Smithers, *Tanystigma tardipes* (Edwards), *Tanystigma edwardsi* (New) and *T. inglewoodense*] have both sections of vein cu_{1a} of the fore wing meeting at an obtuse angle of clearly less than 180°. Those with double-spined phallosomes (*T. notialis, T. bifurcata* and *T. valvula*) all have both sections of the vein almost in a straight line.

Myopsocidae Enderlein

Myopsocus Hagen

Myopsocus Hagen, 1866: 210. Type species: *Psocus unduosus* Hagen.

Myopsocus australis (Brauer)

Psocus australis Brauer, 1865: 908.
Myopsocus australis. — Kolbe, 1883a: 145. For full synonymy see Smithers (1975).

Material examined. 8♀, 6♂, 2 nymphs: site 1 (Jan, Feb 1986), site 2 (Jan, Feb 1986), site 5 (May 1985), site 7 (Jan 1985), site (Jan 1985), site 27, site 29.

Remarks. This widespread species has been recorded from Tasmania, the Bass Strait islands and all mainland states, but not from the Northern Territory. It was collected here from *Casua-*

rina stricta, low eucalypt woodland, tall open forest, closed scrub and open heath.

Discussion

Species discovery curves have been used in comparable studies of psocopteran faunas, to summarise the progressive discovery of species as more individuals are collected over time. An upper asymptote of the number of species discovered indicates that the area has been thoroughly sampled. Randomising the samples excludes phenological effects on the shape of the curve.

The randomised species-individuals discovery curve (fig. 248) suggests that the vegetation types studied were thoroughly sampled. Small patches of *Nothofagus* in very inaccessible regions of the park were not sampled, and this and perhaps one or two other uninvestigated habitats may well yield species additional to those recorded here. The non-randomised species-individuals discovery curve (fig. 249) illustrates the recent discovery of species in newly-sampled areas with habitats broadly similar to those previously sampled, and suggests that further collecting in other areas may yet turn up additional species. The levelling of the non-randomised curve (fig. 249) indicates that the 11 habitats that were systematically sampled were thoroughly investigated, yielding a total of 55 species. Thirteen additional species were collected on occasions outside the 13-month systematic sampling period (2 species prior and 11 after the period) from habitats outside the area that was systematically intensively sampled (Map B, Table 2). In floristic structure these habitats appear similar to those intensively sampled; however there are undoubtedly minor differences in floristic composition, age, aspect, etc. It is estimated that about 90% of the arboreal psocopteran fauna of Wilsons Promontory is now known.

In other surveys of south-eastern Australia accessibility and other factors have restricted sampling to very small parts of the areas under study (Table 4). At Cape Otway National Park sampling sites were near the eastern fringe of the park, such that large areas of the central region and all the western foreshore were not sampled (Thomas, 1986). At Muogamarra Nature Reserve habitats sampled were confined to the area in or near Peats Crater, a somewhat circular area of about 12 ha (Smithers, 1977). The large size and varied topography of the Grampians area suggests that habitats as yet unsampled there may yield additional species. Mt Arapiles, in contrast, is a small, isolated arid area which appears to have been thoroughly sampled (Endersby et al., 1991).

The eastern block of Cape Otway National Park consists of south-eastern slopes of a ridge (that is generally 500–600 m in altitude) of the Otway Range. It is heavily timbered, the vegetation reflecting the high rainfall in the area — one of the wettest in Victoria (Parsons et al., 1977). This region of the park contains 515 vascular plant species (Beauglehole, 1980) compared to 858 species at Wilsons Promontory; it is lower and about one-fifth the size of Wilsons Promontory. The plant species richness of Flinders I. (more than 800 species) is almost double that of King I. (about 430 vascular plant species) (Edgecombe, 1985; Anon, 1972*b*) and Flinders is 26% larger, less disturbed by humans and is higher than King I. At Wilsons Promontory much of the forest has been greatly modified by fire; many of the tall trees have gone and in their place are now extensive areas of closed scrub. Fire is the dominant factor determining present vegetational distribution patterns. Without fire, Lilly-pilly *(Acmena smithii)* would eventually replace much of the present tall open forest, and myrtle beech *(Nothofagus cunninghamii)* would be more widespread (Smith, 1978). Undoubtedly the extensive areas of various scrub and heath plant communities resulting from fires have increased the complexity of vegetation associations at Wilsons Promontory, the complexity being accentuated by interactions between fire, soil, aspect and vegetation. Parsons (1966) has noted the various soil types and vegetation associations of an area near Tidal River.

The different sizes of the psocopteran faunas of King I. (24 species), western Bass Strait, and Flinders I. (38 species), eastern Bass Strait, coincides with differences between Cape Otway (39 species) to the west and Wilsons Promontory (68 species) to the east (Thomas, 1986; Cole et al., 1989). Although sampling effort differs in each of these areas of Bass Strait, there appears to be a correlation between the number of psocopteran species taken and plant species richness, the latter depending, at least in part, on the varying effects of physical relief and fire in the areas concerned.

Somewhat similar patterns of plant communities are evident in Tasmania, where mountains of the west coast receive a very high rainfall under the influence of the roaring forties and the eastern part of the island is much flatter and drier than the west, some areas approaching the

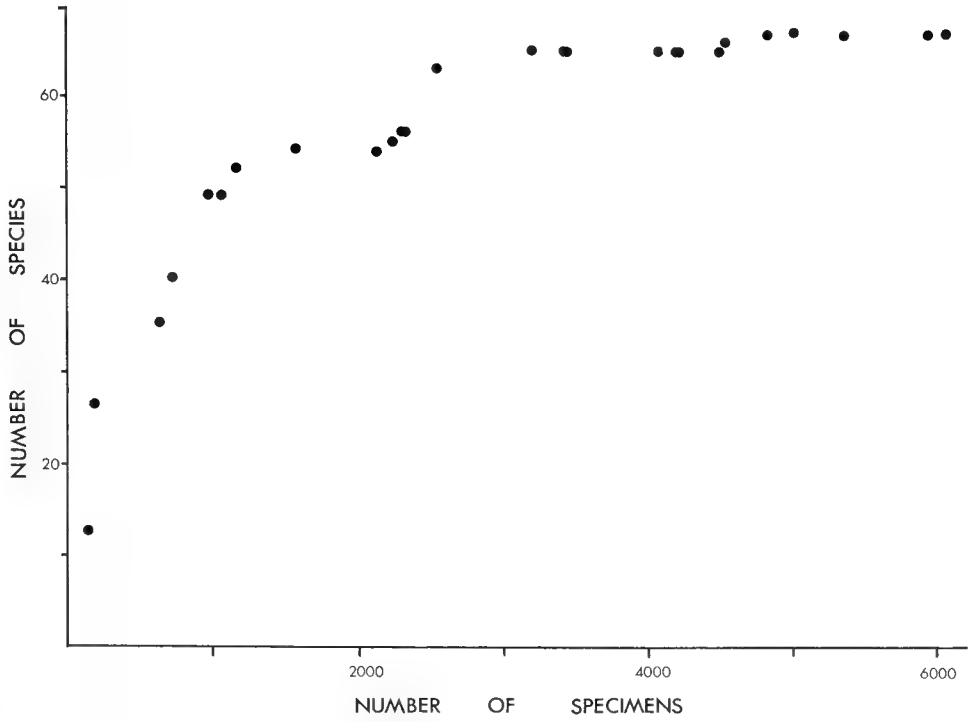


Figure 248. Randomised species-individuals discovery curve of psocopterans at Wilsons Promontory 1982–1991.

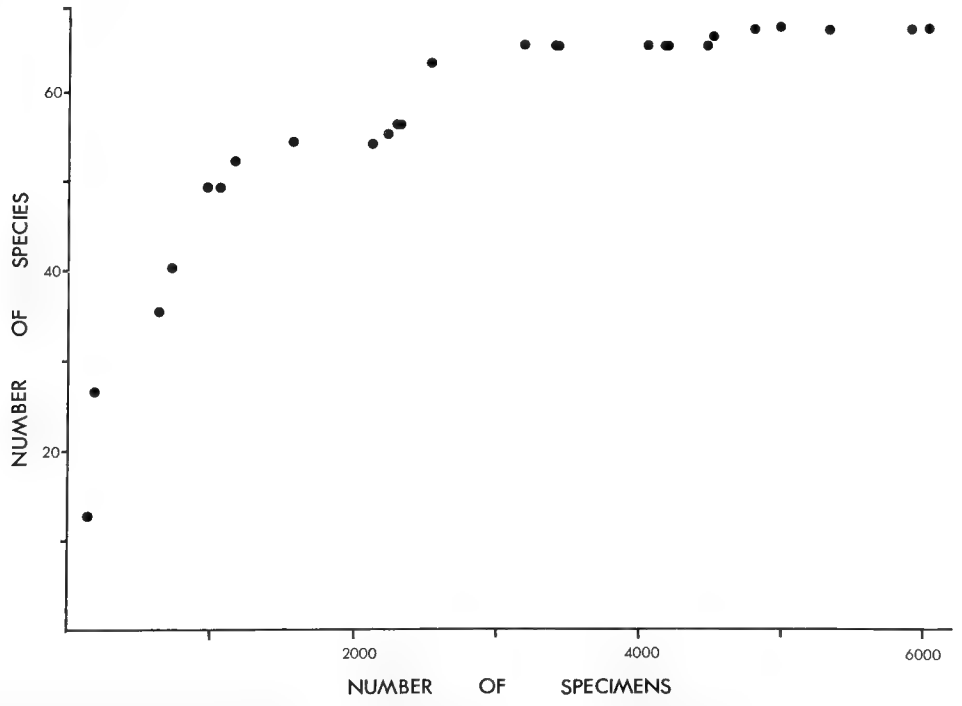


Figure 249. Non-randomised species-individuals discovery curve of psocopterans at Wilsons Promontory 1982–1991. Solid circles indicate data from the systematic survey in 1985 and 1986.

Table 4. Areas of southeastern Australia surveyed for Psocoptera, showing average annual rainfall, species richness (number of genera in brackets) and α diversity.

Region	Wilsons Promontory	Cape Otway	Flinders I.	King I.	Muogamarra	Grampians	Mt Arapiles
Area (ha)	49 000	12 750	137 000	109 000	2 300	167 000	1 500
Rainfall (mm)	1 080	<1 800	650–870	690–1 070	650–950	450–600	
Species (Genera)	68 (25)	39 (14)	38 (18)	24 (14)	43 (24)	32 (15)	
Foliicolous species (genera)	35 (11)	23 (7)	19 (7)	14 (6)	20 (10)	10 (4)	
Corticolous species (genera)	31 (13)	16 (7)	18 (10)	10 (8)	21 (13)	20 (9)	
Total specimens	6 039	763	618	159	684	534	233
α	10.7	8.7	9.0	7.9*	10.2	6.0	2.9*
Period of survey	all year	Feb–Oct	all year		all year	Feb–Nov	
Number of visits	(18)**	(9)	(5)		(23)	(10)	

* Number of specimens too small for reliable α value
** An additional 8 visits were made outside the survey period

low rainfall of Mt Arapiles, Victoria. The vegetation map by Jackson (1965: 31) emphasises the distinction between the wetter environment of the west with its climax cool-temperate closed forest and the drier east with predominantly dry open forest. On soils of high fertility and rainfall, temperate closed forest is simple structurally and floristically; however, this vegetation becomes more complex as a result of interactions between fire frequency and intensity, soil structure and fertility, aspect, and parent rock (Edwards, 1983; Jackson, 1965). Mosaics of closed forest, mixed forest, open eucalypt forests, scrubs, heaths and moorland may predominate in a given area; the number of plant species thus increases with increasing fire frequency and decreasing soil fertility. Without fires, plant communities of the west coast (and north-east highlands) would consist almost exclusively of closed forest (Edwards, 1983). Only thirty-one species of Psocoptera are recorded from Tasmania, predominantly from the drier open forests of the east and north coasts (Edwards, 1950; Hickman, 1934) and several habitats in the south-west (Smithers, 1979). The Tasmanian psocopteran fauna is currently under study; both intensive and extensive sampling has been carried out across the island. The correlation, if any, between species richness of Psocoptera and plants of many different vegetation associations is now under investigation.

The psocopteran α diversity indices of Wilsons Promontory and Muogamarra (Table 4) have been compared with surveys made in other parts of the world (Garcia-Aldrete, 1988), and the indices for islands and archipelagos of the southwest and west Pacific have been compared and discussed by Thornton (1989). The α index is the diversity parameter of the log-series model (Fisher et al., 1943; Southwood, 1978; Taylor et al., 1976). Our data fit a log series (Chi-square tests of goodness fit provide values within the 95% confidence limits of the test) and thus the use of the α index, which also has been used in other studies of psocopteran faunas over the past decade, is valid. In general, the faunas of the areas surveyed in south-eastern Australia (α in the range 6–11) are more diverse than those of England (α = 1.3) and the highlands of East Africa and Jamaica (α = 5.7 and 5.0 respectively) but much lower than the fauna of lowland regions of Trinidad and Panama (α = 12.8 and 19.6 respectively) (Broadhead, 1983) and Chamela (α = 24.0), an area of deciduous tropical forest on the west coast of Mexico where the extremely high species diversity may be related to high floristic diversity (Garcia-Aldrete, 1988).

Foliicolous species (dwelling on living or dead foliage) are comparable in number for Cape Otway, Flinders Island and Muogamarra (Table 4). Their numbers are particularly high at Wilsons Promontory, however, and low at The Grampians – Mt Arapiles and King I. Corticolous species (bark dwellers) are well represented in all surveys except King I., but again more numerous at Wilsons Promontory. In comparison to other surveys of Psocoptera in south-eastern Australia (Table 4) Wilsons Promontory, with 68 species, appears to be the richest of the regions investigated and has the highest diversity. In spite of the more extensive sampling of the promontory than other areas, we believe that the diversity of psocopterans is most probably a reflection of diversity of vegetation associations and hence psocopteran microhabitats available.

Acknowledgements

We are grateful to the National Parks Service for permission to conduct this survey at Wilsons Promontory, to Scott Campbell, Head Ranger, for advice and cooperation, the School of Botany, University of Melbourne for the use of its facilities at Tidal River, and to Ms I. Foley for assistance with arrangements. We also thank the Australian Museum, Sydney, and the Bishop Museum, Honolulu, for the loan of type material in connection with this study. We also wish to thank Ms J. Browning, Ms. J. Kernutt and Mrs T. Carpenter, who made the drawings, and Ms J. Cheah, who typed the manuscript.

References

Aaron, S.F., 1886. On some new Psocidae. *Proceedings of the Academy of Natural Sciences of Philadelphia* 38: 13–18.

Anon., 1972a. *The Ferns and Flowering Plants of Wilson's Promontory National Park.* (Revised Edition). National Parks Service, Victoria.

Anon., 1972b. Plant list for King Island, Bass Strait *Victorian Naturalist* 79: 287–299.

Anon., 1984. *Discovering the Prom on foot.* National Parks Service, Victoria, and Victorian National Parks Association.

Ashton, D.H. and Frankenberg, J., 1976. Ecological studies of *Acmena smithii* (Poir.) Merrill and Perry with special reference to Wilson's Promontory. *Australian Journal of Botany* 24: 453–487.

Aston, D.H. and Webb, R.N., 1977. The ecology of granite outcrops at Wilson's Promontory, Victoria. *Australian Journal of Ecology* 2: 269–296.

Badonnel, A., 1932. Copéognathes de France (IVe

note). *Bulletin de la Société Entomologique de France* 37: 77–79.
Badonnel, A., 1943. Psocoptères. *Faune de France* 42: 1–164.
Badonnel, A., 1946. Psocoptères du Congo Belge. *Revue de Zoologie et de Botanique Africaine* 39: 137–196.
Badonnel, A., 1955. Psocoptères de l'Angola. *Publicacoes Culturais da Companhia de Diamantes de Angola* 26: 1–267.
Ball, A., 1943. Contribution à l'étude des Psocoptères. III. *Bulletin du Musée Royal d'Histoire Naturelle de Belgique* 19: 1–28.
Banks, N., 1903. Some new neuropteroid insects. *Journal of the New York Entomological Society* 11: 236–243.
Banks, N., 1918. New neuropteroid insects. *Bulletin of the Museum of Comparative Zoology at Harvard College* 62: 1–22.
Banks, N., 1939. New genera and species of neuropteroid insects. *Bulletin of the Museum of Comparative Zoology at Harvard College* 85: 439–504.
Beauglehole, A.C., 1980. *The distribution and conservation of vascular plants in the Corangamite-Otway area, Victoria.* Western Victorian Field Naturalists' Clubs Association: Portland.
Blom, W.M., 1988. Late Quaternary sediments and sea-levels in Bass Basin, southeastern Australia – a preliminary report. *Search* 19: 94–96.
Brauer, F., 1865. Vierter Bericht 'ber die auf der Weltfahrt der kais. Fregatte Novara gesammelten Neuropteren. *Verhandlungen Zoologisch-Botanische Gesellschaft in Wien* 15: 903–908.
Broadhead, E., 1983. The assessment of faunal diversity and guild size in tropical forests with particular reference to the Psocoptera. *British Ecological Society Special Publication* 2: 107–119.
Cole, P.G., New, T.R. and Thornton, I.W.B., 1989. Psocoptera of Flinders, King and Deal Islands, Bass Strait. *Journal of the Australian Entomological Society* 28: 31–38.
Curtis, J., 1837. *British Entomology* 14: 648–651.
Edgecombe, J., 1985. *Flinders Island, the Furneaux Group.* Algona: Melbourne.
Edwards, B.A.B., 1950. A study of the Tasmanian Psocoptera with descriptions of new species. *Papers and Proceedings of the Royal Society of Tasmania* 1949: 93–134.
Edwards, I.J., 1983. Vegetation. Pp. 85–91 in: Gee, H. and Fenton, J. (Eds) *The South West Book* Collins/ACF: Melbourne.
Enderlein, G., 1901. Neue deutsche und exotische Psociden, sowie Bermerkungen zur Systematik. *Zoologischen Jahrbüchern. Abtheilung für Systematik, Geographie und Biologie der Thiere* 14: 537–548.
Enderlein, G., 1903. Die Copeognathen des indo-australischen Faunengebietes. *Annales Historico-naturales Musei Nationalis Hungarici* 1: 179–344.
Enderlein, G., 1905. Morphologie, Systematik und Biologie der Atropiden und Troctiden sowie Zusammenstellung aller bisherbekannten recenten und fossilen Formen. *Results of the Swedish Zoological Expedition to Egypt and the White Nile, 1901.* 18: 1–58.
Enderlein, G., 1906. Die australische Copeognathen. *Zoologischen Jahrbüchern, Abtheilung für Systematik, Geographie und Biologie der Thiere* 23: 401–412.
Enderlein, G., 1908. Die Copeognathenfauna der Insel Formosa. *Zoologischer Anzeiger* 33: 759–779.
Enderlein, G., 1924. Copeognathen. In: Damph, A. (Ed.) Zur Kenntnis der estlandischen Moorfauna (11). *Sitzungsberichte. Gesellschaft Naturforschender Freunde zu Berlin* 31: 34–37.
Enderlein, G., 1925. Beiträge zur Kenntnis der Copeognathen. IX. *Konowia* 4: 97–108.
Enderlein, G., 1931. The Percy Sladen Trust Expedition to the Indian Ocean in 1905, under the leadership of Mr J. Stanley Gardiner, M.A. VIII. Die Copeognathen-fauna der Seychellen. *Transactions of the Linnean Society of London (2nd ser. Zoology)* 19: 207–240.
Endersby, N.M., New, T.R. and Thornton, I.W.B., 1990. Psocoptera from the Grampians and Mt. Arapiles, Western Victoria – a biogeographic analysis. *Journal of the Australian Entomological Society* 29: 215–224.
Fisher, R.A., Corbet, A.S. and Williams, C.B., 1943. The relation between the number of species and the number of individuals in a random sample of an animal population. *Journal of Animal Ecology* 12: 42–58.
Garcia Aldrete, A.N., 1988. The psocids (Psocoptera), of Chamela, Jalisco, Mexico. Species, diversity, abundance, distribution and seasonal changes. *Folia Entomologica Mexicana* 77: 63–84.
Garnet, J.R., 1971. *The Wildflowers of Wilson's Promontory National Park.* Lothian: Melbourne.
Hagen, H., 1866. Psocinorum of Embidinorum Synopsis synonymica. *Verhandlungen. Zoologisch-Botanische Gesellschaft in Wien* 16: 201–222.
Heyden, G.H., 1850. Zwei neue deutsche Neuropterengattungen. *Stettiner Entomologische Zeitung* 11: 83–85.
Hickman, V.V., 1934. A contribution to the study of Tasmanian Copeognatha. *Papers and Proceedings of the Royal Society of Tasmania* 1933: 77–89.
Jackson, W.D., 1965. Vegetation. Pp. 30–35 in: Davies, J.L. (Ed.) *Atlas of Tasmania.* Mercury Press: Hobart.
Jennings, J.N., 1959. The submarine topography of Bass Strait. *Proceedings of the Royal Society of Victoria* 71: 49–72.
Jentsch, S., 1939. Beiträge zur kenntnis de Überordnung Psocoidea. 8. Die Gattun *Ectopsocus* (Psocoptera). *Zoologischen Jahrbüchern. Abtheilung für Systematik, Geographie und Biologie der Thiere* 73: 111–128.
Kolbe, H.J., 1880. Monographie der deutschen Psociden mit besonderer Berücksichtigung der Fauna West-falens. *Jahresbericht des Westfälischen*

Provinzial-Vereins für Wissenschaft und Kunst 8: 73–142.

Kolbe, H.J., 1882. Neue Psociden der palaärktischen Region. *Entomologische Nachrichten* 8: 207–212.

Kolbe, H.J., 1883a. Ueber das Genu *Myopsocus* und dessen species. *Entomologische Nachrichten* 9: 141–146.

Kolbe, H.J., 1883b. Neue Psociden des Königl. zoologischen Museums zu Berlin. *Stettiner Entomologische Zeitung* 44: 65–87.

Lee, S.S. and Thornton, I.W.B., 1967. The family Pseudocaeciliidae (Psocoptera) – a reappraisal based on the discovery of new Oriental and Pacific species. *Pacific Insects Monograph* 16: 1–116.

Mackerras, I.M., 1970. Composition and distribution of the fauna. Pp. 187–203 in: *Insects of Australia*. CSIRO: Canberra.

McLachlan, R., 1866. New genera and species of Psocidae. *Transactions of the Entomological Society of London* 5: 345–352.

McLachlan, R., 1899. *Ectopsocus briggsi*, a new genus and species of Psocidae found in England. *Entomologist's Monthly Magazine* 35: 277–278.

Mockford, E.L., 1951. On two North American philotarsids (Psocoptera). *Psyche, a Journal of Entomology* 58: 102–107.

Mockford, E.L., 1959. The *Ectopsocus briggsi* complex in the Americas (Psocoptera, Peripsocidae). *Proceedings of the Entomological Society of Washington* 61: 260–266.

New, T.R., 1971. The Psocoptera of Curtis Island, Tasmania. *Journal of the Australian Entomological Society* 10: 223–229.

New, T.R., 1973a. New species and records of *Peripsocus* Hagen (Psocoptera, Peripsocidae) from southeast Australia. *Journal of the Australian Entomological Society* 12: 340–346.

New, T.R., 1973b. Two new Victorian species of *Ectopsocus* McLachlan (Psocoptera, Ectopsocidae). *Journal of the Australian Entomological Society* 12: 347–351.

New, T.R., 1974a. New species and records of Pseudocaeciliidae (Psocoptera) from southeast Australia. *Journal of the Australian Entomological Society* 13: 65–70.

New, T.R., 1974b. Psocidae (Psocoptera) from southern Australia. *Journal of the Australian Entomological Society* 13: 285–304.

New, T.R., 1977. Psocoptera of the Oriental region: a review. *Oriental Insects Supplementum* 6: 1–83.

Parsons, R.F., 1966. The soils and vegetation at Tidal River, Wilson's Promontory. *Proceedings of the Royal Society of Victoria* 79: 319–354.

Parsons, R.F., Kirkpatrick, J.B. and Carr, G.W., 1977. Native vegetation of the Otways region. *Proceedings of the Royal Society of Victoria* 89: 77–88.

Peck, O., 1951. Superfamily Chalcidoidea. In: Muesebeck, C.F.W., Krombein, K.V. and Townes, H.K. (Eds), Hymenoptera of North America north of Mexico, [synoptic catalog.]. *United States Department of Agriculture. Agriculture Monograph* 2: 410–594.

Perkins, R.C.L., 1899. *Fauna Hawaiiensis*. Cambridge.

Rawlinson, P.A., 1974. Biogeography and ecology of the reptiles of Tasmania and the Bass Strait area. Pp. 291–338 in: Williams, W.D. (Ed.), *Biogeography and ecology in Tasmania*. W. Junk: The Hague.

Reed, K.J., 1959. *The geology of Wilson's Promontory National Park*. Unpublished report. Australian Academy of Science/National Parks' Authority.

Roesler, R., 1943. Über einige Copeognathengenera. *Stettiner Entomologische Zeitung* 104: 1–14.

Roesler, R., 1944. Die Gattungen der Copeognathen. *Stettiner Entomologische Zeitung* 105: 117–166.

Smith, P.G., 1978. *The vegetation of Wilson's Promontory National Park*. National Parks Service, Victoria: Melbourne.

Smithers, C.N., 1962. Insects of Macquarie Island. Psocoptera: Philotarsidae. *Pacific Insects* 4: 929–932.

Smithers, C.N., 1963a. Two new genera of Elipsocidae (Psocoptera) from Australia. *Proceedings of the Royal Entomological Society of London* (B) 32: 32–37.

Smithers, C.N., 1963b. The Elipsocidae of Australia. *Pacific Insects* 5: 885–898.

Smithers, C.N., 1969. The Psocoptera of New Zealand. *Records of the Canterbury Museum* 8: 259–344.

Smithers, C.N., 1974. Two new species and additional records of *Taeniostigma* Enderlein (Psocoptera: Stenopsocidae) from Australia. *Journal of the Australian Entomological Society* 13: 211–217.

Smithers, C.N., 1975. The names of Australian and New Zealand Myopsocidae (Psocoptera). *Australian Entomological Magazine* 2: 76–78.

Smithers, C.N., 1976. The generic position of *Amphigerontia formosa* Banks (Psocoptera: Psocidae) and related species. *Australian Entomological Magazine* 3: 67–73.

Smithers, C.N., 1977. The Psocoptera of Muogamarra Nature Reserve. *Records of the Australian Museum* 31: 251–306.

Smithers, C.N., 1979. Three new species and some records of Psocoptera (Insecta) from Tasmania. *Australian Entomological Magazine* 6: 61–68.

Smithers, C.N., 1983. A reappraisal of *Clematostigma* Enderlein with notes on related genera (Psocoptera: Psocidae). *Australian Entomological Magazine* 9: 71–79.

Smithers, C.N., 1984. The Psocoptera of South Australia. *Records of the South Australian Museum* 18: 453–491.

Smithers, C.N. and Thornton, I.W.B., 1981. The Psocidae (Insecta: Psocoptera) of New Guinea, including a new coleopteriform genus from high on Mount Wilhelm. *Australian Journal of Zoology* 29: 921–969.

Smithers, C.N. and Thornton, I.W.B., 1990. Systematics and distribution of the Melanesian Psocidae

(Psocoptera). *Invertebrate Taxonomy* 3: 431–468.

Southwood, T.R.E., 1978. *Ecological Methods.* Chapman and Hall.

Taylor, L.R., Kempton, R.A. and Woiwood, I.P., 1976. Diversity statistics and the log-series model. *Journal of Animal Ecology* 45: 255–272.

Thomas, S.R., 1986. *A survey of the Psocopteran fauna at Cape Otway National Park, Victoria.* Unpublished Honours thesis, La Trobe University: Bundoora.

Thornton, I.W.B., 1959. A new genus of Philotarsidae (Corrodentia) and new species of this and related families from Hong Kong. *Transactions of the Royal Entomological Society of London* 111: 331–349.

Thornton, I.W.B., 1981. The systematics, phylogeny and biogeography of the Psocopteran family Philotarsidae. *Systematic Entomology* 6: 413–452.

Thornton, I.W.B., 1989. Psocoptera (Insecta) of the island of Moorea, French Polynesia, and comparisons with other Pacific island faunas. *Bulletin de Muséum National d'Histoire Naturelle, Paris (4)* 11: 783–828.

Thornton, I.W.B. and New, T.R., 1977. The Philotarsidae (Insecta: Psocoptera) of Australia. *Australian Journal of Zoology, Supplementary Series* 54: 1–62.

Thornton, I.W.B., New, T.R. and Vaughan, P.J., 1988. Colonisation of the Krakatau Islands by Psocoptera (Insecta). *Philosophical Transactions of the Royal Society of London* B 322: 427–443.

Thornton, I.W.B. and Wong, S.K., 1968. The peripsocid fauna (Psocoptera) of the Oriental Region and the Pacific. *Pacific Insects Monograph* 19: 1–158.

Thornton, I.W.B., Wong, S.K. and Smithers, C.N., 1977. The Philotarsidae (Psocoptera) of New Zealand and the islands of the New Zealand Plateau. *Pacific Insects* 17: 197–228.

Tillyard, R.J., 1923. A monograph of the Psocoptera, or Copeognatha, of New Zealand. *Transactions of the New Zealand Institute* 54: 170–196.

Zimmerman, E.C. 1957. *Insects of Hawaii.* Honolulu.

Memoirs of the Museum of Victoria 53(2): 221 (1992)

REPLACEMENT NAME FOR *ECTOPSOCUS BRUNNEUS* VISHNYAKOVA (PSOCOPTERA: ECTOPSOCIDAE)

By Evan R. Schmidt

Department of Zoology, La Trobe University, Bundoora, Vic. 3083, Australia

Abstract

Schmidt, E.R., 1992. Replacement name for *Ectopsocus brunneus* Vishnyakova (Psocoptera: Ectopsocidae). *Memoirs of the Museum of Victoria* 53: 221.

Ectopsocus vishnyakovae is erected to replace *E. brunneus* Vishnyakova, 1963 preoccupied by *E. brunneus* (Edwards, 1950).

My attention has been drawn by an anonymous reviewer of our paper on the Psocoptera of Wilsons Promontory National Park, Victoria (Schmidt and Thornton, 1992), to the fact that the species name *brunneus* for *Ectopsocus brunneus* Vishnyakova, 1963 has become a secondary homonym of *Ectopsocus brunneus* (Edwards, 1950), transferred to Ectopsocus McLachlan from *Interpsocus* Edwards by Thornton and Wong (1968). A new name is thus required for Vishnyakova's Armenian species to replace the junior homonym.

Ectopsocus vishnyakovae nom. nov.

Ectopsocus brunneus Vishnyakova, V.N. *in* Svadzhyan, R.K., Vishnyakova, V.N. and Mardzhanyan, K.S., 1963: 92, [preoccupied by *Ectopsocus brunneus* (Edwards, 1950: 126, figs 95–102) transferred to *Ectopsocus* by Thornton and Wong, 1968].

References

Edwards, B.A.B., 1950. A study of the Tasmanian Psocoptera with descriptions of new species. *Papers and Proceedings of the Royal Society of Tasmania* 1949: 93–134.

Schmidt, E.R. and Thornton, I.W.B., 1992. The Psocoptera (Insecta) of Wilsons Promontory National Park, Victoria, Australia. *Memoirs of the Museum of Victoria* 53: 137–220.

Svadzhyan, R.K., Vishnyakova, V.N. and Mardzhanyan, K.S., 1963. On the Copeognatha of the Armenian S.S.R. and the methods of their preservation in the laboratory. *Izvestiia-Akademiia Nauk Armianskoi S.S.R. Biologicheskie Nauki* 16 (9): 89–94.

Thornton, I.W.B. and Wong, S.K., 1968. The peripsocid fauna (Psocoptera) of the Oriental Region and the Pacific. *Pacific Insects Monograph* 19: 1–158.

Memoirs of the Museum of Victoria 53(2): 223–226 (1992)

TWO NEW SPECIES OF *NEOHAVINTHUS* MALIPATIL (HETEROPTERA: REDUVIIDAE)

By M. B. Malipatil

Institute of Plant Sciences, Department of Agriculture, Swan Street, Burnley, Victoria 3121, Australia

Abstract

Malipatil, M.B. 1992. Two new species of *Neohavinthus* Malipatil (Heteroptera: Reduviidae). *Memoirs of the Museum of Victoria* 53: 223–226.

Two new species of *Neohavinthus* Malipatil, *N. pronotalis* sp. nov. and *N. trochanteralis* sp. nov., are described from Queensland. A key to the species of *Neohavinthus* is given.

Introduction

The monotypic harpactorine reduviid genus *Neohavinthus* was erected by Malipatil (1991) to include *Harpactor pentatomus* Herrich-Schaeffer from mainland Australia. The present paper describes two new species from Queensland.

In the following descriptions measurements are in millimetres. Unless otherwise indicated, measurements in species descriptions are of the holotype male, followed by ranges of other specimens examined in parentheses.

Specimens are lodged in the Australian Museum, Sydney (AM), Australian National Insect collection, CSIRO, Canberra (ANIC), Museum of Victoria, Melbourne (NMV), Naturhistoriska Riksmuseet, Stockholm (NRS), New South Wales Agriculture, Rydalmere (NSWDA), Queensland Department of Primary Industry, Indooroopilly (QDPI), Queensland Museum, Brisbane (QM), South Australian Museum, Adelaide (SAM), University of Queensland Insect Collection, St Lucia (UQIC), Western Australian Museum, Perth (WAM), Zoologisches Museum, Berlin (ZMB).

Neohavinthus Malipatil

Neohavinthus Malipatil, 1991: 946.

Type species. Harpactor pentatomus Herrich-Schaeffer, 1852 (original designation).

Remarks. The following minor alterations to the original generic description (Malipatil, 1991) must be made to accommodate the new species: antennal segments 1–3 subdivided at proximal ends; paramere well developed or greatly reduced.

Key to species of *Neohavinthus*

1. Pronotum fuscous with humeral angles yellow .. *N. pronotalis* sp.nov.
— Pronotum entirely fuscous 2
2. Legs fuscous with trochanters and bases of femora yellow; labium ending before prosternum .....*N. pentatomus* Herrich-Schaeffer, 1852
— Legs entirely fuscous; labium touching or almost touching prosternum .....*N. trochanteralis* sp.nov.

Neohavinthus pentatomus (Herrich-Schaeffer)

Harpactor pentatomus Herrich-Schaeffer, 1852: 125.

Neohavinthus pentatomus. — Malipatil, 1991: 946.

Types. Lectotype (designated here) male,"Adelaide", "*Harpactor pentatoma* H. Sch.", "2644", "?Typus", ZMB.

Paralectotypes: 1 male, 1 female, "Nov. Holland Coll. Germ.", "8135", "?Typus", ZMB.

Other material examined. Queensland, Atherton, 6 Apr 1948, W.A. Smith, under bark (QDPI, 1 male); Eidsvold (ANIC, 2 nymphs); Bymount via Roma, 17 Aug 1963, T.E. Woodward (UQIC, 1 male). New South Wales, Lightning Ridge, 13 Jul 1977, J.C. LeSouef (SAM, 1 male, 1 female); Watercourse, Moree, Nov 1933, A. Musgrave (AM, 1 male); Dubbo, Oct 1931, J. Armstrong (AM, 1 female); Bogan River, J. Armstrong (AM, 2 males); Bundeena, 7 Aug 1950, G.J. Shanahan, (NSWDA, 1 female); Nymagee, 7 Sep 1976, J. Grigg (ANIC, 1 female). Victoria, Hattah, J.E. Dixon (NMV, 2 males, 1 female); L. Hattah, J.E. Dixon (NMV, 4 males, 9 females); Wimmera, 22 Apr 1916, J.E. Dixon (NMV, 2 females); Kiata, Oct 1928,

F.E. Wilson (NMV, 2 females); Gunbower (NMV, 1 male); Victoria, J.E. Dixon (NMV, 2 females). South Australia, 37 km W of Kimba, 30 Aug 1965, G.F. Gross (SAM, 1 male); Bundaleer (SAM, 1 male); Burnside, 21 Oct 1885, B. Tepper (SAM, 1 female); Mt Lofty, 11 Sep 1883, Tepper (SAM, 1 male); Goolwa, 30 Dec 1962, N.M. Blesing (SAM, 1 female); Scott Creek near Morgan, 12 Apr 1984, H. Mincham (SAM, 1 female); Gammon Ra NP, Arcoona Ck Wild Ass Ck Jn, 6 May 1989, J.A. Forrest, under *Eucalyptus* bark (SAM, 11 males, 11 females). Western Australia, Katanning (WAM 2 males, 2 females); Bold Park, Perth, 26 Oct 1974, R.P. McMillan (1 male), Jun 1975, R.P. McMillan (WAM 1 male); Wannaroo, 12 Oct 1969, E.A. Jefferys and M. Archer (WAM, 1 male); Newman Rocks, 32°07′S, 123°11′E, 1 Apr 1986, R.P. McMillan (WAM, 1 male); Kalamunda, 19 Jun 1963, J. Dell (WAM, 1 male, 1 female); Bickley Valley, 17 Apr 1966, G. Kowtoolas (WAM, 2 females); ca 2 km W of Lake Cronin, 32°23′S, 119°46′E, 19–26 Sep 1981, T.F. Houston et al. (WAM, 1 male); 70–75 km ENE of Norseman, 10–16 Nov 1978, T.F. Houston et al. (WAM, 1 male); Rockingham, 23 Oct 1974, R.P. McMillan (WAM, 1 female); Cadoux, 27 Oct 1981, R.P. McMillan (WAM, 1 female); Nukarni, "36-1646" (WAM, 1 female); Marner, 1909, W.W. Froggatt (ANIC, 1 female); Beverley, 1913, "D'B..?" (ANIC, 1 female); 4 km WSW of Mt Ragged, 33°28′S, 123°26′E, 27–29 Oct 1977, J.F. Lawrence (ANIC, 1 female); Koonalda, 29 Aug 1947, RTMP (NMV, 1 male, 1 female); Wembley, 13 Nov 1947, AB (NMV, 1 male).

Description. Generally fuscous (see fig. 94 of Malipatil, 1991), except for the following yellow: trochanter and bases of femora, distal parts of scutellum, one small area of connexivum and adjoining tergum of each segments 4, 6 and 7 alternating with fuscous areas.

Measurements are of lectotype male first, followed by those of paralectotype female in parentheses.

General body shape as in fig. 94 of Malipatil (1991). Total length 11.39 (13.94); maximum width 3.57 (4.08).

Head. Length 2.38 (2.88); width across eyes 1.53 (1.53); interocular space 0.72 (0.90); interocellar space 0.54 (0.63); eye-ocellar space 0.18 (0.22); eye length 0.54(0.72). Length of antennal segments I 1.62 (1.89); II 0.94 (0.99); III 0.99 (0.99); IV 1.44 (1.44). Length of labial segments: I not measured in lectotype (1.03–1.33); II (1.12–1.26); III (0.35–0.36).

Thorax. Pronotum median length 2.55 (2.88); width posterior margin 2.97(3.33). Scutellum length 0.90 (0.90); width 1.26 (1.35). Femora rather abruptly constricted apically, fore femora ventrally with spinules in addition to tubercles, not arranged in distinct rows, fore femur subequal in length to fore tibia. Length hemelytra 6.46 (7.82); length corium 4.59 (5.61); width membrane 2.21 (2.89).

Male genitalia. Parameres reduced. Other details as in generic description given by Malipatil (1991).

Female genitalia. First valvier broad, styloids inconspicuous (e.g., fig. 4).

Remarks. The Helena Valley (WA) specimen has the antennae and most of fore legs uniformly pale. The Nukarni (WA) specimen exhibits variation in the colouration of legs particularly femora which have broad pale areas.

Neohavinthus pronotalis sp. nov.

Figures 1–4

Types. Holotype male, Mornington Island Mission, Queensland, 8 Jun 1960, P. Aitken and N. Tindale, SAM.

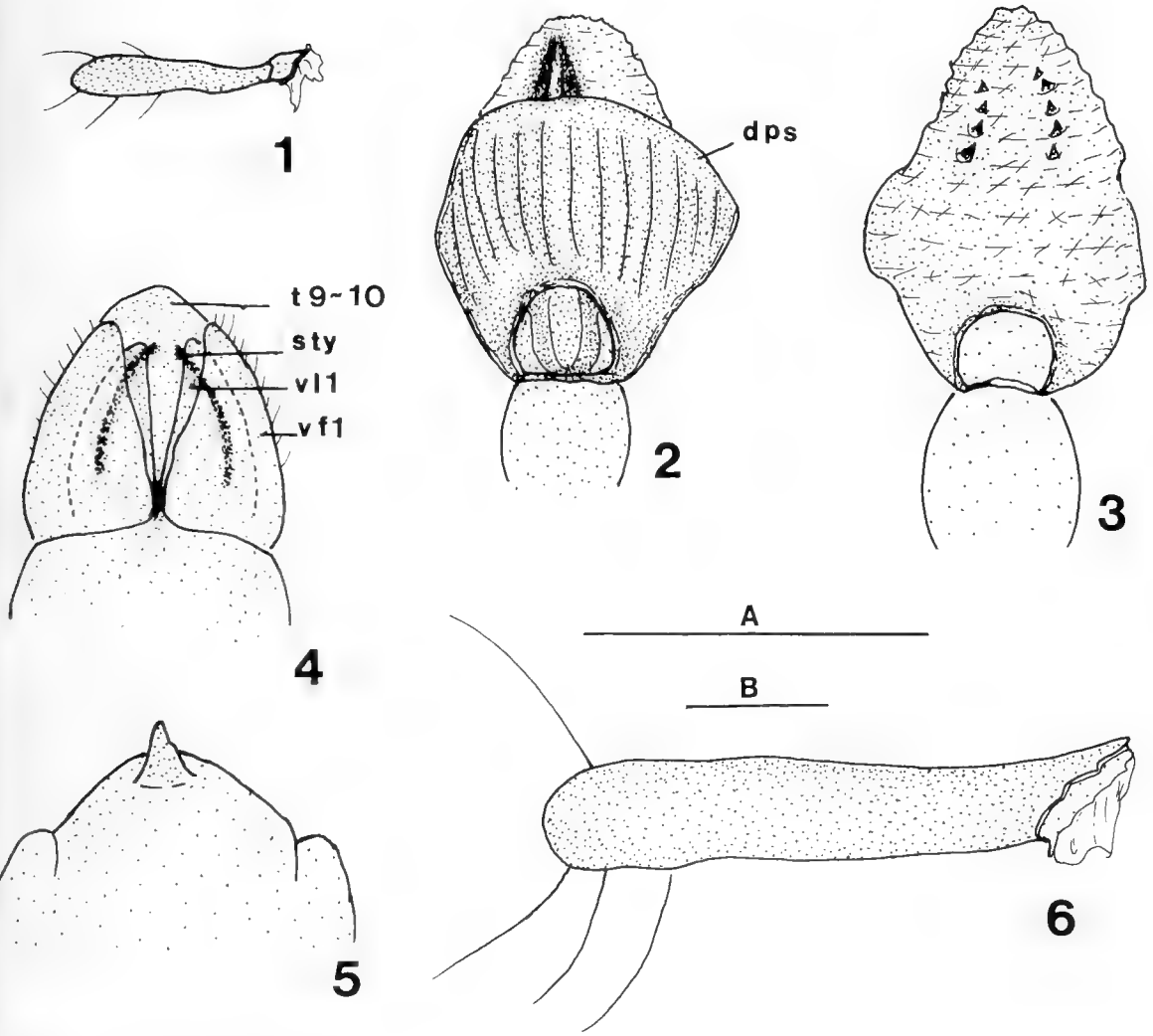
Paratypes. Queensland, same data as holotype except 3 Apr 1960 (SAM, 1 female); Almaden, W.D. Campbell (AM, 1 female); Escott Stn, Burketown, 3 Nov 1930, T.G. Campbell (ANIC, 1 female); Mackay, 20 Jan 1934, M. Powell (QM, 1 male); Kuranda, F.P. Dodd (SAM, 1 male); Brocks Ck, 5 May 1932 (ANIC, 1 male); Peak Downs (NRS, 1 male); Inkerman, 5 Sep 1950, E.F. Riek (ANIC, 1 male); Queensland, 27 Jan 1929, K.K. Spence (AM, 1 male).

Description. Generally fuscous, apices of coxae, trochanters, 2 broad areas one on each humeral angle of pronotum, 3 broad bandlike areas on connexiva, and base of venter of abdomen yellow.

Body and appendages shiny with short bristly hairs in addition to pubescence. Total length 9.66 (8.40–10.78); maximum width 2.52 (2.15–3.40).

Head. Length 2.24 (1.98–2.64); width across eyes 1.18 (1.10–1.25); interocular space 0.53 (0.49–0.57); interocellar space 0.30 (0.30); eye-ocellar space 0.11 (0.14–0.19); eye length 0.60 (0.49–0.60); eye width 0.34 (0.30–0.34). Length of antennal segments I 1.37 (1.25–1.56); II 0.91 (0.76–0.95); III 1.06 (0.91–1.06); IV missing (0.95–1.14). Labium short, ending well before prosternum, length of segments I 0.95 (0.87–0.95); II 1.03 (0.79–1.06); III 0.31 (0.27–0.34).

Thorax. Pronotum median length 2.10 (2.01–2.40); width maximum width 2.45 (2.28–2.69). Fore femora slightly rugulose, ventrally with a few distinct minute spines: 3–6 inner and 2–4 outer indistinct rows, fore tibiae with spinules which are more distinct in female than in male. Scutellum length 0.66 (0.53–0.65); width 1.21 (1.10–1.25). Length hemelytra 5.46 (4.90–6.10);



Figures 1–4. *Neohavinthus pronotalis* sp. nov. 1–3, paratype male: 1, paramere, lateral view; 2, aedeagus, apical part, dorsal view; 3, aedeagus, apical part, ventral view; 4, paratype, female genitalia, ventral view. Abbreviations: dps, dorsal phallothecal sclerite; sty, styloids; t9–10, tergites 9 and 10; vf1, first valvifer; vl1, first valvula.

Figures 5, 6. *Neohavinthus trochanteralis* sp. nov. Paratype male: 5, pygophore, apical part, ventral view; 6, paramere, lateral view. Scale line 0.50 mm. Figs 1–3, 6 to scale A; Figs 4, 5 to scale B.

length corium 3.57 (2.94–3.90); width membrane 1.89 (1.54–2.24).

Male genitalia. Pygophore without a distinct projection on posterior end. Paramere weakly developed, slightly curved in middle (Fig. 1). Aedeagus with dorsal phallothecal sclerite broad, fanlike (Fig. 2); endosomal dorsal surface pigmented in oval area in pairs; ventral surface with 2 rows (1 pair) of almost regular sclerotized spinules (Fig. 3).

Female genitalia. As in Fig. 4.

Remarks. Neohavinthus pronotalis differs from *N. pentatomus* in having a broad yellow area on humeral angles of pronotum; and fore femora with distinct spinules in two indistinct rows and also spinules on fore tibia more distinct in female than in male.

The species name, *pronotalis*, alludes to the pronotum with broad yellow areas on its humeral angles – a major diagnostic character of the species.

Neohavinthus trochanteralis sp. nov.

Figures 5, 6

Types. Holotype male, Maryborough, Queensland, SAM.

Paratypes. Queensland, Millstream Falls via Ravenshoe, 10 Dec 1966, B. Cantrell (UQIC, 1 female); Rockhampton (NRS, 1 female); Maryborough (SAM, 1 female); Carnarvon Range, Dec 1941, N. Geary (AM, 1 male); Biggenden, Mt Walsh NP, Bluff Range, 12 Aug 1971, H. Frauca (ANIC, 1 female).

Description. Generally fuscous with tibia, antenna and lateral area of corium paler. Following yellow: bases of hemelytra and wings, lateral areas of scutellum ; connexiva with alternate fuscous and yellow areas.

Body and appendages except hemelytra and wings densely covered with bristly hairs in addition to pubescence; also patches of scalelike white pubescence near pronotal constriction, on lateral areas of scutellum and yellow areas of connexivum. Total length 10.22 (10.90–13.02); maximum width 3.04 (2.70–3.50).

Head. Length 2.69 (2.81–3.19); maximum width 1.44 (1.40–1.52); interocular space 0.66 (0.60–0.64); interocellar space 0.45 (0.38–0.44); eye-ocellar space 0.19 (0.19–0.21); eye length 0.67 (0.61–0.76); eye width 0.30 (0.42–0.44). Length antennal segments I 1.78 (1.60–2.12); II 0.98 (0.79–0.83); III 1.06 (0.87–1.14); IV segment strongly curved, measurements only approximate 1.82 (1.60–2.35). Labium almost touching prosternum, length of segments I 1.29 (1.30–1.52); II 1.52 (1.45–1.78); III 0.38 (0.45–0.49).

Thorax. Pronotum median length 2.43 (2.36–2.66); maximum width 2.73 (2.81–3.11). Femora granulate, fore femora in addition with minute spicules not in regular rows; also fore tibia in male unarmed, in female with minute spinules. Scutellum length 0.69 (0.72–0.75); width 1.21 (1.33–1.50). Length hemelytra 5.88 (6.33–7.42); length corium 4.06 (4.34–4.76); width membrane 2.00 (2.00–2.38).

Male genitalia. Pygophore with a distinct median projection on posterior end (Fig. 5). Paramere well developed, almost straight (Fig. 6). Aedeagus as in *N. pronotalis* sp. nov.

Female genitalia. As in *N. pronotalis* sp. nov., except first valvifer narrower.

Remarks. Neohavinthus trochanteralis differs from *N. pronotalis* in having a well developed paramere; and the humeral angles of pronotum and bases of femora not yellow.

The species name, *trochanteralis*, alludes to the trochanter which is fuscous as rest of the leg – a diagnostic character of the species.

Acknowledgements

I thank M. Moulds (AM), M. Carver (ANIC), A. Neboiss and K. Walker (NMV), P. Lindskog (NRS), G. Brown (NSWDA), J. Donaldson (QDPI), G. Monteith (QM), G. Gross (SAM), M. Schneider (UQIC), T. Houston (WAM) and U. Gollner-Scheiding (ZMB) for the loan of specimens; G. Gross for reading through the manuscript.

References

Herrich-Schaeffer, G.H.W., 1852. *Die Wanzenartigen Insekten.* C. H. Zehüschen Buchhandlung: Nurnberg. Vol. 9: 125.

Malipatil, M.B., 1991. The generic classification of the Australian Harpactorinae (Heteroptera: Reduviidae). *Invertebrate Taxononomy* 4: 935–971.

Memoirs of the Museum of Victoria 53(2): 227–266 (1992)

NEW CUCUMARIID HOLOTHURIANS (ECHINODERMATA) FROM SOUTHERN AUSTRALIA, INCLUDING TWO BROODING AND ONE FISSIPAROUS SPECIES

By P. Mark O'Loughlin and Timothy D. O'Hara

Department of Invertebrate Zoology, Museum of Victoria, Melbourne, Victoria 3000, Australia

Abstract

O'Loughlin, P.M. and O'Hara, T.D., 1992. New cucumariid holothurians (Echinodermata) from southern Australia, including two brooding and one fissiparous species. *Memoirs of the Museum of Victoria* 53: 227–266.

Twelve new species of cucumariid holothurians are described from off the coast of southern Australia. *Pentocnus* gen. nov. is erected for one species which has no interradial plates in the calcareous ring. *Cucuvitrum* gen. nov. (1 species), *Squamocnus* gen. nov. (1 species) and *Apsolidium* gen. nov. (3 species) are erected for species with combinations of body and ossicle form not represented in known genera. The other species are assigned to *Neocnus*, *Trachythyone* (2 species), *Ocnus*, *Neocucumis* and *Neocucumella*. The new species of *Pentocnus* and *Neocnus* brood their young. The new species of *Squamocnus* is fissiparous. The new species of *Cucuvitrum* is host to a copepod parasite (Cucumaricolidae).

Introduction

Southern Australian holothurians are known mainly from the works of Ludwig (1874), Bell (1887), Joshua (1912, 1914), Joshua and Creed (1915), Erwe (1913), H.L. Clark (1914, 1938, 1946), Hickman (1962, 1978), A.M. Clark (1966), Rowe (1976, 1982) and Rowe and Vail (1982). Including those described herein, 23 cucumariid species are now known from the Australian states of Victoria, Tasmania, South Australia and from the south-west of Western Australia (Table 1). Of these, 5 are abundant and well known for the region: *Psolidiella adhaerens* Hickman, 1962, *Staurothyone inconspicua* (Bell, 1887), *Pentacta ignava* (Ludwig, 1874), *Cucumella mutans* (Joshua, 1914) and *Neoamphicyclus lividus* Hickman, 1962. These have been described in detail by Hickman (1962) (*P. ignava* as *P. australis*), and current distribution and habitat notes given by one of the us (M.O'L.) in Marine Research Group of Victoria (1984). *Amphicyclus mortenseni* Heding and Panning, 1954, also described by Hickman (1962), occurs in deeper water in eastern Bass Strait.

Some essentially tropical species extend around the coast of Western Australia into the Great Australian Bight (Rowe, 1982). These are: *Mensamaria intercedens* (Lampert, 1885); *Pentacta crassa* (Ekman, 1918); *Pentacta quadrangularis* (Troschel, 1846); and *Pentacta anceps* (Selenka, 1867). *Cucumaria bicolor* Bell, 1887 (see Heding and Panning, 1954: 92) and *Cucumaria striata* Joshua and Creed, 1915 (see A.M. Clark, 1966: 345) have been referred to the synonymy of *Mensamaria intercedens*.

Joshua (1914) recorded the Indo-Pacific cucumariid *Plesiocolochirus spinosus* (Quoy and Gaimard, 1833) from "Victorian waters". The ill-defined locality data with the specimens in the Museum of Victoria create doubt about its occurrence in the region.

Joshua (1914) and Joshua and Creed (1915) recorded from southern Australia the New Zealand species *Pseudocucumis* (=*Neocucumella*) *bicolumnatus* (Dendy and Hindle, 1907), the South American species *Cucumaria* (=*Neopsolidium*) *convergens* (Herouard, 1901), and the subantarctic species *Cucumaria* (=*Trachythyone*) *squamata* (Ludwig, 1898). Rowe (1982) recorded *Ocnus calcareus* (Dendy, 1896) from off south-western Australia. This material has been re-examined by us and in all four cases has been assigned to new species. H.L. Clark (1946: 389) proposed the name *Cucumaria squamatoides* for the specimen of *C. squamata*, but, as A.M. Clark (1966: 345) pointed out, this name is a nomen nudum, failing to meet the criteria under ICZN Article 13 and is replaced herein.

Extensive collecting of echinoderms from the southern Australian coast by us and with associates since 1978 has revealed many new holothurian species. Most of the specimens were collected off algae or rocks in the rocky shallows, in depths of 0–2 m, and representatives of these species were observed live before preservation. Other specimens, including material from the continental shelf, were examined from the collections of the Museum of Victoria (NMV), the Australian Museum (AM), the South Australian Museum (SAM), the Western Australian

Museum (WAM), the Tasmanian Museum (TM), the New Zealand Oceanographic Institute (NZOI) and the Museum of Comparative Zoology, Harvard (MCZ).

Two of the new species brood their young: the *Neocnus* species in two marsupia in the anterior dorsal body wall, and the *Pentocnus* species in pouches on the internal anterior body wall. Seasonal coelomic brooding has been reported for two south-eastern Australian cucumariids: *Staurothyone inconspicua* (Bell, 1887) and *Neoamphicyclus lividus* Hickman, 1962 (see Materia et al., 1991).

Terminology

Terminology predominantly follows Clark and Rowe (1971) or Pawson (1970). Ossicle types include cups (pl. 4c), rosettes (pl. 7f), tables (fig. 8c), buttons (pl. 9a), plates (pl. 7d), multilayered ossicles (pl. 3b), pedicel endplates (pl. 6g), bar-like ossicles (pl. 9e), mesh-like ossicles (small plates in pl. 6h) and rods (pl. 2h). All podia or tube feet are referred to as pedicels. A sole is a flattened, delimited modification of the ventral body wall with peripheral pedicels which do not extend to the introvert or anus (pl. 2b). The term radii is used in preference to ambulacra (following Pawson, 1970). Left and right are relative to facing anteriorly along the dorsal surface.

Order **Dendrochirotida** Grube, 1840 (restricted by Pawson and Fell, 1965)

Cucumariidae Ludwig, 1894

Remarks. The relationships between "cucumariid" and "phyllophorid" holothurians have been confused. Panning (1949) and Heding and Panning (1954) define the Cucumariidae and the Phyllophoridae predominantly on the basis of the number of tentacles, ten in the Cucumariidae and more than ten in the Phyllophoridae. Pawson and Fell (1965) consider that the nature of the calcareous ring is fundamental, placing genera with posterior processes in the Phyllophoridae and those without in the Cucumariidae. However, Clark and Rowe (1971), Hickman (1978) and Cannon and Silver (1987) have continued to use the older basis for classification. Pawson and Fell's classification is used in this paper. Consequently the subfamily Thyonidiinae (e.g., *Cucumella* Ludwig and Heding, 1935 and *Neoamphicyclus* Hickman, 1962) with 15–30 tentacles and simple calcareous ring is included in the Cucumariidae, and the subfamily Thyoninae (e.g. *Thyone* Oken, 1815) with ten tentacles and conspicuous posterior processes on the calcareous ring is considered to be in the Phyllophoridae.

The taxonomy within the Cucumariidae is also currently confused and ill-defined, particularly between the subfamilies Colochirinae and Cucumariinae. Panning (1949), in his revision of the Cucumariidae (which included the final breakup of old heterogeneous taxa such as *Cucumaria* de Blainville, 1834 and *Thyone* Oken, 1815), distinguished the Colochirinae from the Cucumariinae by the presence of cup-shaped ossicles in the body wall of the former. However, many of the species in the Cucumariinae, as then defined, were subsequently found to have cups or cup-like derivatives, or at least plates similar in form to genera in the Colochirinae. Panning (1971) finally restricted the Cucumariinae to two genera, *Cucumaria* and *Cladodactyla* Brandt, 1835 without, however, publishing emended diagnoses for these genera or either subfamily.

Panning (1962, 1964, 1966, 1971) further restricted the diagnoses of many of the genera within the Colochirinae. Consequently recent regional studies (Rowe, 1970; Rowe and Pawson, 1985; Thandar, 1985, 1986, 1987; Gutt, 1990; this paper) have added a plethora of new genera as new or existing species could no longer be satisfactorily placed in existing genera. This has led to a more natural classification, recognizing structural differences between ossicle types, but more research is necessary, particularly on the derivation of the various cup ossicles.

Panning (1971) attempted to divide the Colochirinae into three distinct groups, based on the number of ossicle types present and their function. An "Ocnus" group with two types of body wall ossicles, a "Pentacta" group with three, and the genus *Pseudocnus* with special denticulate plates which function as cups, giving the skin adhesive traction. But this division is unnatural as many of the species in the "Ocnus" group have three types of body wall ossicles, not the two required, and *Pseudocnus* is not the only genus to use denticulate body wall plates to achieve traction.

The phylogeny of the Cucumariidae poses many problems, particularly due to the apparent incidence of convergent evolution. Panning (1971), mainly after Pawson (1966), listed the following characters as primitive: posterior extensions on the calcareous ring; pedicels restricted to the radii; and an imbricating armour of multi-layered scale-like ossicles

Table 1. Nomenclatorial history of southern Australian cucumariid species.

This Paper	Rowe, 1982	H.L. Clark, 1946	Joshua, 1914 Joshua and Creed, 1915
Colochirinae			
Staurothyone inconspicua (Bell, 1887)	*Staurothyone inconspicua*	*Staurothyone inconspicua*	*Cucumaria inconspicua*
Pentocnus bursatus gen. et sp. nov.			
Cucuvitrum rowei gen. et sp. nov.	*Pseudocnus* sp.		
Neocnus bimarsupiis sp. nov.			
Psolidiella adhaerens Hickman, 1962	*Psolidiella adhaerens*		
Squamocnus aureoruber gen. et sp. nov.			
Trachythyone candida sp. nov.	*Trachythyone* sp.	*Psolidium* sp.	*Psolidium convergens* (Herouard, 1901)
Trachythyone glebosa sp. nov.			
Apsolidium handrecki gen. et sp. nov.			
Apsolidium densum sp. nov.			
Apsolidium alvei sp. nov.	*'Cucumaria' squamatoides*	*Cucumaria squamatoides* H.L. Clark, 1946	*Cucumaria squamata* Ludwig, 1898
Ocnus occiduus sp. nov.	*Ocnus calcareus* (Dendy, 1896)		
Pentacta ignava (Ludwig, 1874)	*Pentacta ignava*	*Pentacta australis* (Ludwig, 1874)	*Colochirus doliolum* (Pallas, 1766)
Pentacta crassa (Ekman, 1918)	*Pentacta crassa*	*Pentacta crassa*	
Pentacta quadrangularis (Troschel, 1846)	*Pentacta quadrangularis* (Lesson, 1830)	*Pentacta quadrangularis* (Troschel)	*Colochirus quadrangularis* Lesson, 1830
Pentacta anceps (Selenka, 1867)	*Pentacta anceps*		
Plesiocolochirus spinosus (Quoy and Gaimard, 1833)	*Plesiocolochirus spinosus*	*Apentacta spinosa*	*Colochirus spinosus*
Thyonidiinae			
Amphicyclus mortenseni Heding and Panning, 1954	*Amphicyclus mortenseni*	*Mensamaria thomsoni* (Hutton, 1879)	
Neoamphicyclus lividus Hickman, 1962	*Neoamphicyclus lividus*		
Cucumella mutans (Joshua, 1914)	*Cucumella mutans*	*Mensamaria thomsoni* (Hutton, 1879)	*Cucumaria mutans*
Mensamaria intercedens (Lampert, 1885)	*Mensamaria intercedens*	*Mensamaria intercedens* *Cucumaria striata* Joshua and Creed, 1915 *Cucumaria bicolor* Bell, 1887	*Cucumaria striata*
Neocucumella fracta sp. nov.	*Neocucumella bicolumnata* (Dendy and Hindle, 1907)	*Mensamaria bicolumnata*	*Pseudocucumis bicolumnatus*
Neocucumis cauda sp. nov.			

covering the whole body. No extant cucumariid genus has all of these characters, but some genera, e.g., *Leptopentacta* H.L. Clark, 1938, do possess small extensions to the radial plates in the calcareous ring, and non-imbricating multilayered ossicles.

Colochirinae Panning, 1949

Pentocnus gen. nov.

Diagnosis. Worm-like form, lacking sole or modified ventrum; 10 irregularly developed dendritic tentacles; calcareous ring discontinuous, 5 spaced radial plates without posterior prolongations, no interradial plates; pedicels present on all radii, absent interradially. Body wall ossicles small, elongate, perforated, flat or saucer-like, often denticulate plates, with blunt vertical spines; lacking true cups; pedicels with similar plates to body wall, and endplates; tentacles with irregular perforated bar-like ossicles, small perforated plates and rods.

Type species. Pentocnus bursatus sp. nov.

Etymology. From the Greek *pente* (five), in reference to the plates in the calcareous ring, with *Ocnus* (masculine).

Remarks. The lack of interradial plates in the calcareous ring, the irregular development of the tentacles, the delicate form of the ossicles, and the other possible paedomorphic characters, clearly distinguish *Pentocnus* from all other genera within the Cucumariidae. The shallow, saucer-like, spined form of the plates suggests a possible form or functional relationship with the cup ossicles present in other cucumariid genera. The denticulate body wall plates possibly indicate some relationship with the genus *Pseudocnus* Panning, 1949.

Some cucumariid genera have reduced interradial calcareous ring plates, but no other dendrochirotid genus lacks them completely. In the subfamily Thyonidiinae, *Athyonidium* Deichmann, 1941 has very reduced interradials, often obscured by muscle; the resulting ring is also discontinuous. In *Amphicyclus* Bell, 1884 the interradials are also reduced, but they adjoin the larger radial plates in a continuous ring.

Pentocnus bursatus sp. nov.

Plates 1a, 2e–g, Figure 1

Pseudocnus sp. — Rowe and Vail, 1982: 224.

'cucumariid' sp. — O'Loughlin, 1991: 225–226, fig. 4.

Material examined. Holotype. Victoria, Cape Paterson, rocky shallows, algal and sponge epifauna, 14 Feb 1981, M. O'Loughlin, M. Nyhuis and C. Walker, NMV F57549.

Paratypes. Victoria, Cape Paterson, type locality and date, AM J22754(1); NMV F58629(1 juv); 18 Jan 1980, NMV F54236(1); rocky shallows, algal epifauna, 6 Mar 1983, NMV F53762(1); 29 Jan 1988, NMV F54181(1).

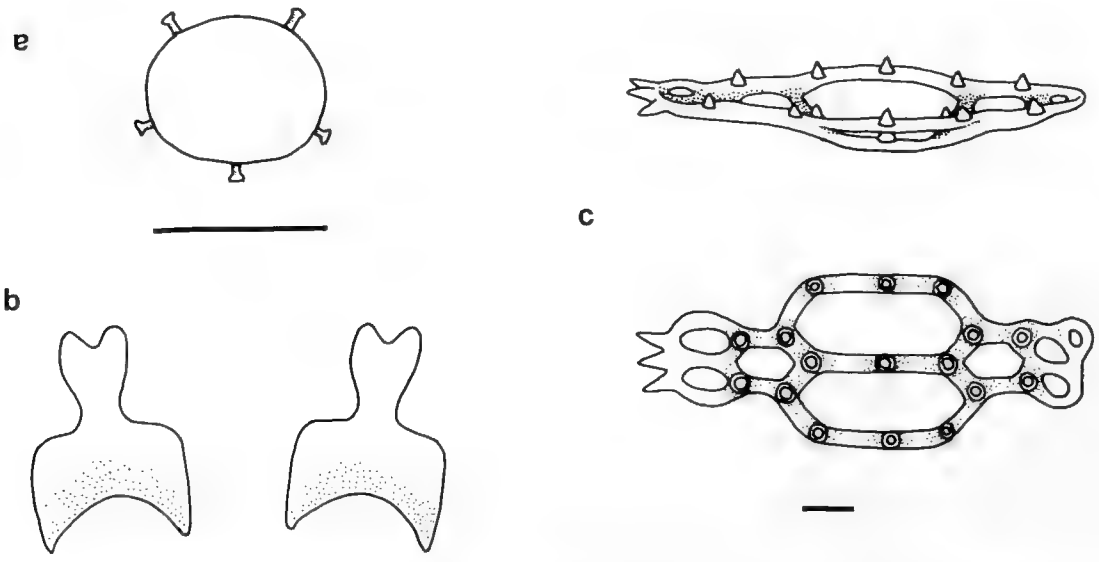


Figure 1. *Pentocnus bursatus* gen. et sp. nov.: a, transverse section of body, scale bar = 1.0 mm; b, 2 adjacent radial plates from the calcareous ring; c, side and top view of a dorsal body wall plate, scale bar = 0.01 mm.

South Australia, Beachport, 37°29.3'S, 139°59.6'E. 4 m, 14 May 1990, NMV F59207(1).

Other material. Western Australia, Rottnest I., Cape Vlamingh, outer reef flat, 9 Jan 1991, WAM 239-91(1); Radar Reef, *Sargassum/Cystophora* mat, 13 Jan 1991, WAM 255-91(1).

Description. Up to 15 mm long (live, extended), 1 mm wide; body worm-like, round in transverse section, lacking sole or modified ventrum, introvert not distinct, mouth anterior, anus posterior; body wall thin, very extensible; 10 dendritic tentacles, very irregularly developed, about 6 fully developed, about 4 small or bud-like. One row of pedicels on each radius, with up to 18 pedicels in a row, slightly more numerous ventrally; interradial areas lacking pedicels. Calcareous ring comprises 5 spaced radial plates, no interradial plates; no posterior prolongations; anterior projections constricted basally, widened and rounded distally with apical notch; wide, deep, rounded notch posteriorly, creating pairs of pointed projections (the 5 plates of the calcareous ring are clearest in specimens NMV F57549, NMV F53762, NMV F59207, WAM 239-91.) Dorsal madreporite; single, left to ventral, polian vesicle.

Body wall ossicles of one type: small, elongate, perforated plates, with blunt vertical spines, often denticulate, flat or shallow saucer-like, up to 0.09 mm long; typical plate with 2 large central holes, one smaller hole near each end, 1–6 very small holes at ends; plates frequently denticulate at one end or one side; ossicles may imbricate or be spaced in extended body wall. Pedicels with body wall plates; endplates with irregular angular perforations, about 0.1 mm wide. Tentacles with small irregular plates with large angular perforations, up to 0.07 mm wide; abundant irregular rods with divided, twisted, perforated ends, sometimes branched, typically 0.07 mm long; a few large, irregular, branched, perforated bar-like ossicles, up to 0.13 mm long; a few elongate rosettes up to 0.05 mm long; some body wall plates, lacking spines.

Live colour. Body and pedicels reddish brown; end rim of pedicels dark reddish brown; tentacle trunks brown, branches faintly reddish brown; colour persists in alcohol.

Reproduction. The holotype (6 mm long, tentacles withdrawn) has a dorsal gonad, 1 brood embryo and 1 brood juvenile. The gonad has 5 sac-like caeca, graded in size, the smallest caeca with 1–2 small white eggs, the largest caecum with 1 brown egg or embryo (0.3 mm long). The brood embryo is dark brown, ovoid, undifferentiated (0.8 mm long). The brood juvenile is well-differentiated (1.4 mm long). Both are together in the coelom in a membranous sac which is attached to the anterior, left ventral body wall. There is no change in the body wall at the point of attachment, nor any apparent aperture to the exterior.

NMV F54236 (10 mm long, tentacles withdrawn) has a dorsal gonad, 3 brood embryos and 2 juveniles. The gonad has 6 sac-like caeca, graded in size, the 3 smallest with about 3 small white eggs, and the 3 largest each with one large developing brown egg or embryo (up to 0.8 mm long). One brood embryo is in the coelom near the gonad. Two other brood embryos showing radial pedicels, and 2 well-developed brood juveniles (up to 2.3 mm long) are associated with a thin-walled sac in the anterior left lateral coelom. The sac is attached to the interradial body wall where there is a body wall fold and opening. NMV F54181 (8 mm long) has 2 undifferentiated embryos with firm brown ovoid cases (1 mm long). Each embryo is in a thin-walled sac which has a small growth attachment to the coelomic body wall. One is in the left dorsolateral mid-body, the other in the right ventral anterior. At the point of attachment of the anterior embryo the body wall has broken down to create a small opening. A gonad with a few small white eggs is present. AM J22754 (8 mm long, tentacles not withdrawn) has 2 undifferentiated embryos (one in a gonad caecum, 0.7 mm long), an embryo with radial pedicels, and a well-developed juvenile (2.2 mm long) in a membranous sheath in the left anterior coelom. NMV F53762 (5 mm long) had 3 brood embryos (up to 1.5 mm long) in separate thin sacs attached to a scar or fold in the body wall, one in the right dorsolateral coelom in the mid-body, 2 close together in the left ventrolateral coelom anteriorly. There is only part of the gonad remaining. NMV F59207 (5 mm long; tentacles withdrawn) has one well-developed bursal juvenile attached to the right anterior intracoelomic body wall, and a gonad with one large and a few small white eggs.

Etymology. From of the Greek *bursa* (purse), with reference to the intracoelomic sacs in which brood juveniles develop.

Distribution. Rottnest I., Western Australia, to Cape Paterson, Victoria. 0–4 m.

Remarks. This very small species reproduces by brooding in intracoelomic sacs which are randomly attached to the anterior body wall.

Embryos or juveniles may be present singly or together in the sacs. The very thin-walled sacs lack ossicles and appear to be derived from the egg rather than from the body wall. At the point of attachment of the sacs, with their developing embryos or juveniles, the body wall may undergo change, is sometimes gathered into a small fold, and may break down to create a small opening. Individuals produce few eggs but may have all reproductive stages present, from small egg to fully-developed brood juvenile. Only one egg appears to mature at any one time. All six adults exhibit bursal coelomic brooding. All observed gonads contain eggs and are similar in form, suggesting hermaphroditic or pathenogenic reproduction. The collection of brooding adults in January, February, March and May suggests non-seasonal reproduction.

Ocnus sacculus Pawson, 1983, from New Zealand, has a similar brooding habit. Intracoelomic sacs are attached to the dorsal interradial anterior body wall and contain up to 9 embryos. The internal sac walls are thin and transparent. The body wall forming the external wall of the sac has fewer ossicles than elsewhere, and Pawson (1983: 228) suggests that "birth" occurs by rupture of the body wall. This species is easily distinguished from *P. bursatus* by the form of the calcareous ring, the form of the ossicles, body form, and distribution of pedicels.

P. bursatus, known from only three widely separated localities, is found amongst algal tufts and sponge in the rocky shallows.

Cucuvitrum gen. nov.

Diagnosis. 10 dendritic tentacles, ventral 2 smaller; pedicels mostly confined to radii, a few scattered on dorsal and lateral interradii. Body wall ossicles numerous knobbed perforated plates, irregularly oval, some with the end or one side denticulate, some large multi-layered ossicles; tentacles and pedicels with bar-like perforated ossicles; pedicels with endplates. Calcareous ring simple, without posterior prolongations; 10 plates tapered anteriorly, notched posteriorly.

Type species. Cucuvitrum rowei sp. nov.

Etymology. From the Latin *vitrum* (glass), in reference to the glassy multi-layered ossicles in the body wall, with part of the family name, Cucumariidae (neuter).

Remarks. The combination of the following characters – knobbed plates, multi-layered ossicles, pedicels mostly confined to radii, and ventral tentacles reduced – does not exist in any previously described cucumariid genus and warrants the creation of a new taxon. Of the other genera, *Pseudocnus* Panning, 1949 and *Pseudocnella* Thandar, 1987, are most similar. However, *Pseudocnus* lacks multi-layered ossicles and *Pseudocnella* has ten equal tentacles, interradial papillae, and reduced cups.

Cucuvitrum rowei sp. nov.

Plates 1b, 3a–g, Figure 2

Stereoderma sp. — A.M. Clark, 1966: 346–347, fig. 9.

Pseudocnus sp. — Rowe, 1982: 466, fig. 10.32b, pl. 32.2. — Rowe and Vail, 1982: 223.

Material examined. Holotype. Victoria, Cape Paterson, just below low tide level, 18 Jan 1980, M. O'Loughlin, T. O'Hara and J. Stephenson, NMV F57356.

Paratypes. Victoria, type locality and date, NMV F54241(5); Apollo Bay, Marengo, Hayley Point, just below low tide level, 11 Jan 1980, NMV F54240(2).

Other material (partial list; all found as algal epifauna, 0–2 m, unless otherwise stated; # indicates material with intracoelomic copepod parasites).

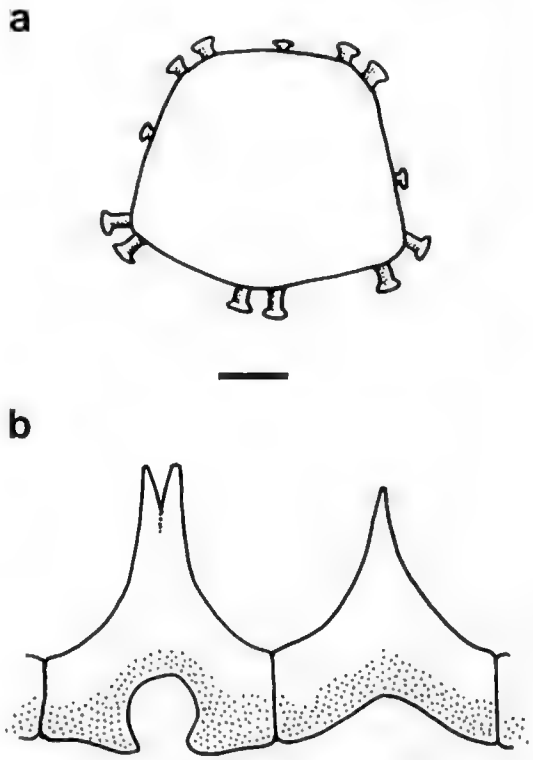


Figure 2. *Cucuvitrum rowei* gen. et sp. nov.: a, transverse section of body, scale bar = 1.0 mm; b, radial and interradial plates from the calcareous ring.

Western Australia, Rottnest I., Strickland Bay, 20 Jan 1991, WAM 400-91(1 juv); Natural Jetty, 15 Jan 1991, WAM 393-91(1 juv); Cape Naturaliste, Eagle Bay, 25 Feb 1975, WAM 556-89(13).

South Australia, Ceduna, Cape Vivonne, 16 Jan 1991, NMV F59209(4); Streaky Bay, Point Westall, 15 Jan 1991, NMV F59211(1); Greenly I., 28 Nov 1976, SAM K1800(1); Arno Bay, 22 Feb 1988, 2–3 m, SAM K1813(1); Kangaroo I., Emu Bay, 17 Jan 1990, NMV F57550(1); Gulf St Vincent, Normanville, 11 Nov 1988, NMV F54386(1); Robe, 9 Jan 1990, NMV F57551(1).

Victoria, Cape Otway, Crayfish Bay, 31 Dec 1980, NMV F54221(1 and 1 juv); 10 km NE of Apollo Bay, "Mullet Holes", 6 Jan 1981, NMV F57949(4); NMV F57948(1#); 10 Jan 1987, NMV F54218(5); NMV F58640(1#); Port Phillip Bay, Altona, 14 Sep 1980, NMV F54228(8); NMV F58641(1#); Williamstown, 11 Apr 1990, NMV F58643(1#); NMV F59208(5); 38°17′S, 144°38′E, 3–6 m, 30 Mar 1986, SPPS stn 3B1, NMV F57547(6#); Portsea Jetty, 4 m, 13 Mar 1975, AM J10857(1); Cape Schanck, Bushrangers Bay, 28 Mar 1981, NMV F54224(3 juv); Flinders, Mushroom Reef, 16 Nov 1990, NMV F59206(1); Merricks, 27 May 1989, NMV F54395(2); Phillip I., Kitty Miller Bay, 13 Feb 1988, NMV F54215(5); 1 km E of Harmers Haven, 300 m offshore, 4.5–6 m, 6 Mar 1982, CPA stn 15, NMV F53772(2); Cape Paterson, 28 Apr 1989, NMV F54394(5); NMV F58642(1#); Shack Bay, 4.5–12.2 m, 4 Mar 1982, CPA stn 4, NMV F53771(1); Wilsons Promontory, Hobbs Head, 12.5 m, 9 Feb 1982, WPNPA stn 42, NMV F53773(1 juv); Rabbit I., 23 Apr 1983, NMV F53783(2); eastern Bass Strait, 39°0′S, 147°30.5′E, 28 m, 28 Jan 1971, NMV F59203(1); Cape Everard, 8 Apr 1984, NMV F57943(2); Mallacoota, Bastion Point, 5 m, 6 Apr 1989, NMV F57363(6); Gabo I., 4 m, 4 Apr 1989, NMV F57364(1).

Tasmania, King I., Rocky Cape, 2 m, 15 Mar 1988, NMV F57361(5); Lulworth, Black Rock Point, 22 Nov 1982, NMV F53788(2); Waterhouse Passage, 23 Nov 1982, NMV F53789(2); Bicheno, 7 m, 22 Mar 1988, NMV F57544(4); Swansea, 8 km S, 4 m, 21 Mar 1988, NMV F57360(5); NMV F57548(2#); Eaglehawk Neck, 15 Feb 1991, NMV F59216(1); Tinderbox, 29 May 1974, AM J10855(1); D'Entrecasteaux Channel, Esperance Point, 13 m, AM J22665(7#); Bruny I., Adventure Bay, 15 m, 23 Apr 1991, AM J22667(3#); Sadgrove Point, 7 Mar 1974, AM J10856(1); Southport, Lady Bay, 3 m, 11 Oct 1977, AM J11164(1).

New South Wales, Disaster Bay, Green Cape Lighthouse, 16 m, 13 Feb 1973, AM J12548(1); Twofold Bay, 3 m, 29 Mar 1985, AM J19909(6); Eden, Cocora Point, 25 Nov 1984, NMV F53786(3); Jervis Bay, 3 m, 26 Nov 1971, AM J12547(1); Bondi, 3–5 m, Oct 1977, AM J11167(5); Port Jackson, 3 m, 29 Aug 1977, AM J10883(2); Manly, 9 Oct 1979, AM J12735(2); Nambucca Heads, 13 m, 11 Jan 1972, NMV F57555(1#); Coffs Harbour, 13 m, 22 Jan 1982, AM J15470(2).

Description. Up to 21 mm long (tentacles partly withdrawn), 4 mm wide and high; body elongate, slightly keeled midventrally, distinct dorsolateral and ventrolateral edges, body pentagonal in transverse section; weakly developed oral valves formed by anterior radial body wall projections; mouth orientated anteriorly; extensible anal cone, often upturned; body wall firm, crystalline, with microscopic vitreous spots; 10 dendritic tentacles, 2 ventral ones distinctly smaller; distinct modified ventrum, not a sole; distinct introvert, lacking pedicels; 5 anal teeth. Pedicels in 2 rows on all radii, extending to introvert and anus; ventrolateral and midventral radii with up to 60 pedicels in each row; dorsolateral series irregular, pedicels small; a few small pedicels interradially on dorsal and lateral surfaces, used for grit attachment; single very extensible small pedicels on each radius anteriorly and around anus. Calcareous ring lacking posterior prolongations; 5 radials with blunt anterior projections, often notched, large notch posteriorly; interradials with pointed anterior projections, wide shallow posterior scallops. Madreporite dorsal; single polian vesicle left lateral; intestine runs dorsally from mouth to mid-coelom, loops left back to mouth, then runs ventrally to anus.

Dorsal body wall ossicles of 5 types: 1) Abundant perforated plates, heavily knobbed, irregularly oval, frequently thick and rounded at an end or edge, the opposite side or end denticulate; some plates fir-cone shaped, wide end smooth, narrow end denticulate; many plates with projections, bars, further developing layers, commonly up to 0.12 mm long; closely situated in 2 or more layers within the body wall. 2) Scattered large multi-layered ossicles, irregularly oval, up to 0.48 mm long, with 3–5 perforated knobbed layers of decreasing size, one end sometimes denticulate. 3) A few irregular smooth perforated plates, up to 0.12 mm long. 4) A few irregular smooth or lumpy or knobbed button-like ossicles, typically 0.07 mm long. 5) Rosettes in some New South Wales specimens (AM J10883, AM J12735), up to 0.04 mm long. Plates of ventrum similar to dorsum; multi-layered ossicles less developed. Plates of introvert fewer, similar to body wall, more finely knobbed, none multilayered. Pedicels with irregular, bent or curved, perforated bar-like ossicles, often widened centrally, often denticulate and finely knobbed along outer edge, typically 0.14 mm long; endplates up to 0.25 mm wide, smaller perforations centrally; irregularly triangular, perforated, curved, denticulate plates, typically 0.1 mm wide; sometimes rosettes, 0.04 mm long. Tentacles with flat to bar-like thick ossicles,

elongate, irregular, often widened centrally, perforated centrally and distally, sometimes curved, often bent at centre, up to 0.26 mm long; irregularly round to triangular, thin, perforated, slightly convex, denticulate plates, up to 0.08 mm wide; rosettes, typically 0.04 mm long.

Live colour. Body predominantly white, golden in largest specimen, sometimes dark flecking dorsally and laterally; dark vitreous spots dorsally and laterally; tentacle branches pale yellow to golden, with brown to black marking on tentacle trunks extending to varying degrees onto introvert. Gold, yellow colours lost rapidly in alcohol.

Reproduction. Some sac-like gonad caeca and gonoducts have been observed in the right dorsolateral coelom. Most of the many specimens are juveniles, and have been collected during summer and autumn.

Etymology. Named in recognition of the contribution by Dr F.W.E. Rowe to this paper and to echinoderm research in Australia.

Distribution. Rottnest I., Western Australia, to Coffs Harbour, New South Wales, including Tasmania. 0–28 m.

Remarks. One, rarely two, copepod parasites are sometimes present in the coelom of *C. rowei* specimens from Victoria, New South Wales and Tasmania (see # in Material examined for exact locations). Dr G.C.B. Poore (Museum of Victoria, pers. comm.) has provisionally identified them as *Cucumaricola* sp. in the family Cucumaricolidae. They are long and narrow, sometimes extending more than half the length of the coelom, and carrying numbers of yellow eggs.

Rosette ossicles are present in the body wall of some material from New South Wales. These specimens are otherwise similar to those from other regions, and to specimens from New South Wales without rosettes, and are thus included in the current species.

Most of the specimens have been collected as algal epifauna and are juveniles. A few adults have been found attached to the undersurface of rocks.

Neocnus Cherbonnier, 1972

Diagnosis (emended from Cherbonnier, 1972). Body short and stout with distinct sole; 10 dendritic tentacles, ventral 2 smaller; pedicels confined to periphery and mid-ventral radius of sole. Body wall ossicles rare, a few perforated rods or plates present posteriorly. Tentacles with thin perforated rods; pedicels without endplates. Calcareous ring simple, without posterior prolongations, 10 plates, tapered anteriorly, undulating posterior edge. Dorsal marsupia present.

Type species. Neocnus incubans Cherbonnier, 1972.

Remarks. This genus was previously known only from the type species found on the Mediterranean coast off Tunisia.

Two superficially similar genera, *Pseudopsolus* Ludwig, 1898 and *Microchoerus* Gutt, 1990, also have simple ossicles, a sole, and pedicels predominantly restricted to the ventral radii. However, *Pseudopsolus* also has ten equal tentacles, four polian vesicles, rare or numerous, knobbed or smooth perforated plates in the body wall, and is hermaphroditic. *Microchoerus* has knobbed perforated plates, which reduce in density as body size increases, and lacks dorsal marsupia.

Orbithyone H.L. Clark, 1938, known only from the type species *O. megapodia* H.L. Clark, 1938, found off Western Australia, is also characterized by an almost total lack of ossicles. However, it differs in having a distinctive calcareous ring, numerous rosettes as well as rods in the tentacles, no sole, and numerous large pedicels with well-formed endplates covering the whole body.

Neocnus bimarsupiis sp. nov.

Plates 1c, 2h, Figure 3

Neocnus sp. — Rowe and Vail, 1982: 224. — O'Loughlin, 1991: 223–225, figs 2, 3.

Material examined. Holotype. Victoria, Apollo Bay, Marengo, Hayley Point, just below low tide level, 29 Dec 1979, M. O'Loughlin, NMV F54238.

Paratypes. Type locality, NMV F54239(120); AM J22752(20).

Other material (partial list; all collected as algal epifauna, 0–2 m, unless otherwise stated).

South Australia, Robe, 10 Jan 1988, NMV F54183(40).

Victoria, Cape Bridgewater, 20 Jan 1979, NMV F53806(1); Cape Otway, Crayfish Bay, 31 Dec 1980, NMV F53814(47); Apollo Bay, Marengo, Hayley Point, 11 Jan 1980, NMV F53808(75); Flinders, east of Mushroom Reef, 13 Jul 1990, NMV F58630(7); Shoreham, 18 Oct 1980, NMV F53813(4); Phillip I., E of Pyramid Rock, 22 Dec 1980, NMV F53810(1); Kilcunda, 26 Jan 1987, NMV F53805(13); Harmers Haven, 300 m offshore, 4.5–6 m, 6 Mar 1982, CPA stn 15, NMV F53781(1); Cape Paterson, 29 Jan 1988, NMV F54182(8).

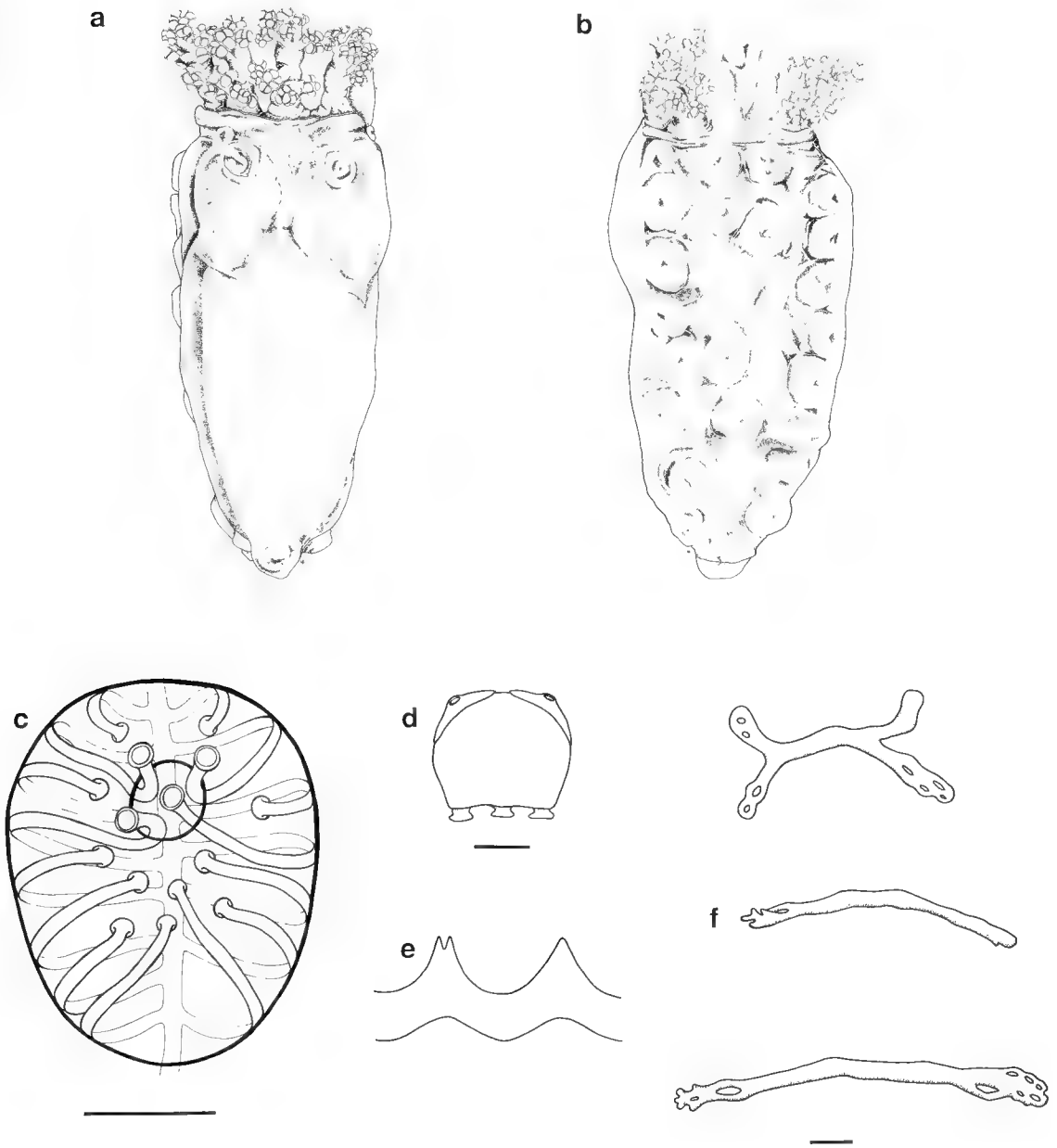


Figure 3. *Neocnus bimarsupiis* sp. nov.: a, dorsal body view, showing paired anterior marsupia; b, ventral body view, showing extensible ventral tentacles; c, diagram of a marsupium, showing interior dorsal pedicels, with 4 extending through opening, scale bar = 0.5 mm; d, transverse section of body, scale bar = 1.0 mm; e, adjacent radial and interradial plates from the calcareous ring; f, tentacle rod ossicles, scale bar = 0.01 mm.

Tasmania, Lulworth, Black Rock Point, 22 Nov 1982, NMV F53787(15).

Description. Up to 6 mm long, 3 mm high, 2.5 mm wide; body roughly egg-shaped; tentacles orientated anteriorly or slightly upturned, anus posterodorsal; 2 dorsal brood pouches in anterior body wall except in juveniles, each with external round aperture, and small interior pedicels which may extend through the aperture; body wall thin, soft; 10 dendritic tentacles, 2 ventral ones small, slightly lobed, extensible to 3.0 mm long, with a pedicel-like attaching capability; distinct sole; introvert not distinct from body wall. Sole with peripheral row of up to 20 large pedicels, up to 4 anterior ones aligned transversely; up to 4 irregularly on midventral radius; not extending to introvert and anus; mostly no pedicels on lateral or dorsal surfaces, except some within the dorsal marsupia and frequently single small radial pedicels anteriorly, most prominent dorsolaterally; up to 5 small pedicels around anus. Calcareous ring lacking posterior prolongations; 10 plates with similar anterior tapered projections, posterior scallops; radials with small anterior notch. Madreporite dorsal; single polian vesicle left lateral; intestine ventral, with full loop extending coelom length, single additional short dorsal loop near anus.

Body wall mostly lacking ossicles, a few rods in dorsal, anal body wall; sole lacking ossicles. Pedicels lacking endplates or ossicles. Tentacles with abundant thin straight and curved rods, typically 0.08 mm long; ends of rods swollen, with 1–6 small holes or notches, divided end of rod often twisted together; rods rarely with side branches or forks. Ossicles similar in juveniles.

Live colour. Body dark to very dark grey or brown; sole, pedicels, tentacles to varying degrees lighter in colour; colour persists in alcohol.

Reproduction. All observed gonads contain eggs and are similar in form, suggesting hermaphroditic or pathenogenic reproduction. All adults (July to April) with similar mature gonads and brood juveniles; gonad dorsal, with up to 8 sac-like caeca, graded in size from bud to fully-developed; largest caeca lie against wall of brood pouch, each caecum with up to 13 large yellow eggs or embryos and a few small white eggs interspersed; large eggs or embryos frequently 0.6 mm long, up to 1.2 mm long; small caeca with up to 15 small white eggs. Short anterior dorsal gonoduct; gonopore between bases of dorsal tentacle pair. Two separate anterior dorsal brood pouches sit radially within body wall, separated from coelom, exterior to dorsolateral radial muscle band; each pouch with central aperture; series of up to 16 very small pedicels within each pouch, may extend out of the pouch aperture. Each brood pouch with up to 14 embryos or juveniles, uniform in size, differentiation evident at 0.7 mm long; brood juveniles up to 1.5 mm long.

Etymology. From the Latin *bini* (two) and *marsupium* (pouch, ablative case), with reference to the two brood pouches.

Distribution. Robe, South Australia, to Cape Paterson, Victoria, and north-eastern Tasmania. 0–6 m.

Remarks. This species is similar to *N. incubans*. Both are small and epiphytic, brood their young in marsupia in the anterior dorsal body wall, and have tentacle rods as the main ossicle form. *N. incubans* differs in having small irregular perforated plates as well as rods in the tentacles, rods of a different shape, rods and small plates in some posterior pedicels, rare large smooth perforated plates in the body wall, and only one large marsupium which contains up to 30 eggs or embryos and juveniles.

In *N. bimarsupiis* the method of transfer of eggs or embryos from the gonad to the marsupia is not known. With the extensible attaching ventral tentacles, and the small suckered pedicels extending through the marsupium opening, there is a capacity for transfer of eggs or embryos from gonopore to marsupium. Numbers of eggs in a mature gonad sac, and of brood juveniles in a marsupium, are similar. If there is a single action of transfer from one mature gonad sac to one marsupium, the action would be remarkably efficient. Since no brood juveniles with fully developed tentacles and mouth have been found in the marsupia, it appears that brood juveniles complete their development to a stage of independent nutrition outside the marsupium.

N. bimarsupiis is found on algae, particularly brown algae, e.g. *Zonaria angustata* (Kuetz), in the rocky shallows, where it appears as a very small, dark, soft but tough, oval protuberance on the algal fronds. Its relatively large ventral pedicels enable it to cling strongly to its substrate.

Squamocnus gen. nov.

Diagnosis. 10 dendritic tentacles, ventral 2 smaller; 5 oral valves; pedicels on ventral radii and scattered on dorsal radii and interradii. Body wall ossicles cups, knobbed perforated but-

tons and large multi-layered ossicles; pedicels with perforated bar-like ossicles and endplates; tentacles with perforated bar-like ossicles, small mesh-like plates and rosettes. Calcareous ring simple, with undulating posterior margin and anterior tapers.

Type species. *Squamocnus aureoruber* sp. nov.

Etymology. From the Latin *squama* (scale) in reference to the multi-layered ossicles in the body wall, with *Ocnus* (masculine).

Remarks. Several existing cucumariid genera have similar ossicles. *Leptopentacta* H.L. Clark, 1938 differs in having short posterior "tails" on the radial plates in the calcareous ring and pedicels restricted to the radii. *Loisettea* Rowe and Pawson, 1985 has deep complex cups, elongate calcareous ring plates and (at least on the type species) large papillae on the radii. *Trachythyone* Studer, 1876 has a similar body form, but has smooth single-layered plates as the main ossicle form. *Ocnus* Forbes, 1841 has similar knobbed buttons and cups, but lacks multi-layered plates and the pedicels are restricted to the radii.

Several little-known forms, previously referred to *Ocnus* or *Trachythyone*, are possibly better placed in *Squamocnus*. *O. brevidentis* (Hutton, 1872), from New Zealand, is possibly congeneric. Unfortunately, there has been considerable variation in the descriptions of this species. Dendy (1896) and Panning (1949) found multi-layered ossicles, knobbed buttons, cups and scattered dorsal pedicels in their specimens. Mortensen (1925) described "large, smooth plates"; Pawson (1970) made no mention of large plates at all. Possibly more than one species is involved.

O. syracusanus (Grube, 1840) from Europe has pedicels distributed on both radii and interradii, reduced ventral tentacles, reduced cups, knobbed buttons and multi-layered ossicles with a pronounced denticulate end. It has been recently referred to *Pseudocnella* by Thandar, 1987, but the other species in that genus have 10 equal tentacles and pedicels restricted to the radii.

O. kerguelensis (Theel, 1886) with scattered dorsal pedicels, reduced ventral tentacles, multi-layered ossicles, knobbed buttons and x-shaped ossicles, is possibly related. *Trachythyone amokurae* (Mortensen, 1925), from New Zealand, has cups, smooth and knobbed buttons and large multi-layered ossicles in the dorsal body wall. Some of these multi-layered ossicles are extended at one end into a "spine". Pedicels are biserially arranged on the radii with a few scattered on the mid-dorsal interradius.

O. farquhari (Mortensen, 1925) and *O. sacculus* Pawson, 1983, also from New Zealand, have similar ossicles to *Squamocnus*, but lack any pedicels on the dorsal surface and probably deserve their own genus as Pawson (1983) suggests.

We have not had the opportunity to examine these species so final placement cannot be determined with certainty.

Squamocnus aureoruber sp. nov.

Plates 1d, 4a–h, Figure 4

Trachythyone sp. — Rowe and Vail, 1982: 222 (part). — O'Loughlin, 1991: 223, fig. 1.

Material examined. Holotype. Victoria, Cape Paterson, just below low tide level, 18 Jan 1980, M.

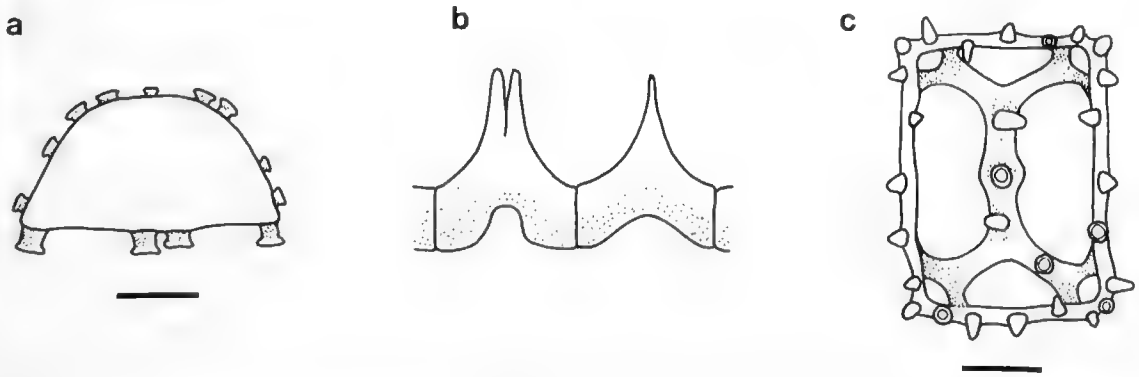


Figure 4. *Squamocnus aureoruber* gen. et sp. nov.: a, transverse section of body, scale bar = 1.0 mm; b, adjacent radial and interradial plates from the calcareous ring; c, top view of a dorsal body wall cup, scale bar = 0.01 mm.

O'Loughlin, T. O'Hara and J. Stephenson, NMV F54244.

Paratypes. Type locality and date, NMV F54243(69); NMV F58622(1*); Apollo Bay, Marengo, Hayley Point, just below low tide level, 11 Jan 1980, NMV F54242(11).

Other material (partial list; all found as algal epifauna, 0–2 m, unless otherwise stated; * indicates fissiparous specimens).

South Australia, Streaky Bay, Point Westall, 15 Jan 1991, NMV F59210(2); Robe, 10 Jan 1988, NMV F54703(4); NMV F58623(2*); 9 Jan 1990, NMV F57552(4*); Port MacDonnell, 8 Jan 1988, NMV F54705(13).

Victoria, Cape Otway, Crayfish Bay, 31 Dec 1980, NMV F53801(15); Marengo, 2 Jan 1990, NMV F57553(6*); 10 km NE of Apollo Bay, "Mullet Holes", 2 Jan 1988, NMV F54702(8); NMV F58626(1*); Lorne, Grey Point, 14 Jun 1982, NMV F53798(1); Bushrangers Bay, 28 Mar 1981, NMV F53804(1); Flinders, E of Mushroom Reef, 6 Mar 1982, NMV F53799(7); 13 Jul 1990, NMV F58631(1); 11 Aug 1990, NMV F58638(10*); NMV F58635(1); Shoreham, 18 Oct 1980, NMV F53796(3); NMV F58625(1*); Phillip I., Cowrie Beach, 27 Nov 1985, NMV F53802(11); NMV F58628(1*); Harmers Haven, 6 Mar 1982, CPA stn 23, NMV F53777(1); Cape Paterson, 14 Feb 1981, NMV F53803(18); NMV F58624(1*); 28 Apr 1989, NMV F54393(24); NMV F58627(1*); Inverloch, Eagles Nest, 4.5–7.6 m, 5 Mar 1982, CPA stn 3, NMV F53779(2).

Tasmania, Rocky Cape, 2 m, 15 Mar 1988, NMV F57365(1); Greens Beach, mouth of Tamar River, 7 Mar 1981, NMV F53790(2); Lulworth, Black Rock Point, 22 Nov 1982, NMV F53791(2 juv); Bicheno, 7 m, 22 Mar 1988, NMV F59229(1).

Description. Up to 10 mm long (tentacles withdrawn), 1.7 mm high, 3 mm wide; body dome-like with slight dorsolateral angles in transverse section, flattened ventrally, rounded posteriorly, with extensible upturned anal cone; 10 dendritic tentacles orientated anteriorly, 2 ventral ones small; body wall thin, microscopically scaly; distinct flat, very thin-walled ventrum, not sole; very thin-walled introvert, lacking pedicels; 5 small radial oral valves which project partly over introvert; anus with 5 fine teeth. Ventral radii each with 2 irregular rows of pedicels, up to 40 in a row; pedicels large on mid-ventral and ventral rows of lateroventral radii; distinctly smaller on dorsal row of lateroventral radii, near anus and introvert; not extending onto introvert. Pedicels scattered dorsally, laterally, in irregular double rows on dorsal radii; single very extensible small pedicels on each anterior radial projection of body wall; 5 small extensible pedicels around anus. Calcareous ring lacking posterior prolongations; 5 radials with posterior notch, anterior taper and notch, slightly higher than interradials; 5 interradials with posterior scallop, pointed anteriorly. Madreporite dorsal; single polian vesicle left lateral; intestine runs dorsally from mouth to mid-coelom, loops back to ring, then runs ventrally to anus.

Dorsal body wall ossicles of 5 types. 1) A surface layer of abundant small spinous cups, 2–3 times as wide as deep, typically 0.04 mm long; typically rectangular, with 4 large and 4 small corner holes; rim and cross thin, with short spines pointing mainly vertically out from cup. 2) Some shallow cups, slightly irregular, frequently 8-holed, only slightly spinous or lacking spines, 0.04–0.09 mm long. 3) Large, imbricating, knobbed, regularly perforated, often multilayered ossicles, predominantly 2-layered, very irregularly oval, typically 0.3 mm long, up to 0.5 mm long. Knobs on developing plates join to create bars and secondary layers. 4) Knobbed and smooth buttons, frequently 4-holed, many fairly regular, typically 0.09 mm long. 5) Smooth, slightly convex, irregularly oval, perforated plates; holes large centrally, small peripherally; typically 0.1 mm wide. Ventral body wall with cups, buttons, convex plates, large plates with secondary developments but not multilayered. Pedicels with endplates, 0.18 mm wide; flat and elongate to bar-like ossicles, frequently bent and curved and widened centrally and distally, perforated, irregular, up to 0.18 mm long. Tentacles with irregular, large to small, bar-like ossicles, some curved and bent and branched, perforated, up to 0.2 mm long; some irregular, convex, mesh-like, denticulate plates, 0.08 mm wide; rosettes, up to 0.05 mm long.

Live colour. Body, including ventral surface and pedicel walls, reddish orange often with slight dark flecking; ends of pedicels pale; tentacles yellow, with dark brown on trunks and introvert; all colour except dark markings lost rapidly in alcohol.

Reproduction. All observed gonads contain eggs and are similar in form, suggesting hermaphroditic or pathenogenic reproduction. The mature gonads have eggs or embryos in January (NMV F58626), February (NMV F53803), March (NMV F53799), July (NMV F58631) and August (NMV F58635). Gonad dorsal, up to 8 caeca graded in size, largest caeca with up to 15 yellow eggs or embryos interspersed with fewer small white eggs; eggs or embryos up to 0.7 mm long; short anterior dorsal gonoduct; gonopore between bases of dorsal tentacles.

Some specimens show evidence of fissiparity. Fission commences with a transverse growth change and constriction around the mid-body (NMV F54243). The constriction deepens and begins to separate the anterior and posterior halves (NMV F58623, F58624). The two ends finally separate by moving apart, as evidenced by the long connecting thread of body wall remaining in one specimen (NMV F58622). Matching and recently separated anterior and posterior ends have been found together (NMV F57553). Most large collections have one or a few with atypical round or short body form, and lack a calcareous ring and tentacles in some cases (NMV F57553) or the characteristic form of the posterior end in other cases (NMV F58623). One specimen is an posterior end with ring and tentacles at a very early development stage (NMV F58625).

Etymology. From the Latin *aureus* (golden) and *ruber* (red), in reference to the colour.

Distribution. Streaky Bay, South Australia, to Inverloch, Victoria, including northern Tasmania. 0–8 m.

Remarks. S. aureoruber can be distinguished from the similar species listed above in the generic remarks by the body wall ossicles, a combination of well-developed cups, rare knobbed buttons and oval multi-layered ossicles.

Evidence of fissipary in *S. aureoruber* has been found throughout its geographical range, in small and large specimens, and in summer and winter. Direct observation of fission has not yet been undertaken. Preserved material provides strong evidence that fissipary is a significant recruitment process. Mature gonads with eggs have been found in several specimens, indicating that recruitment is both sexual and asexual. Evisceration has not been observed, and this phenomenon would not provide an explanation for the absence of a calcareous ring and tentacles in some atypically short specimens.

Emson and Wilkie (1980: 161) noted that six holothurian species have been found to reproduce by fission, including two *Ocnus* species from the Cucumariidae. In *Ocnus planci* (Brandt, 1835) division usually occurs by twisting or stretching, muscles contract, and the pedicels pull in different directions until the tissues are severed.

Specimens have been found predominantly on algae in the rocky shallows.

Trachythyone Studer, 1876

Diagnosis (based on species currently assigned to the genus). 10 dendritic tentacles, ventral 2 usually smaller; pedicels on radii, sometimes also scattered on dorsal and lateral interradii. Body wall ossicles cups overlying numerous large perforated plates; plates usually smooth, rarely with some minor lumps, up to 0.95 mm long; often some knobbed buttons; cups small, shallow, sometimes spinous, sometimes replaced by rudimentary x-shaped ossicles. Tentacles and pedicels with perforated rods or plates; endplates present. Calcareous ring simple, without posterior prolongations, 10 plates, tapered anteriorly, posterior notches.

Type species. Trachythyone muricata Studer, 1876.

Remarks. The genus *Trachythyone* was revived by Panning, 1949 who assigned 21 species. He subsequently (1964) severely restricted the genus, referring (1966) many of the original species to *Leptopentacta* H.L. Clark, 1938. Panning (1964) suggested that one of the remaining species, *T. crucifera* (Semper, 1869), from the Indian Ocean, with its spiny cruciform plates, probably requires its own genus. *T. amokurae* (Mortensen, 1925) from New Zealand, with its multi-layered ossicles, is not a *Trachythyone* (see *Squamocnus* remarks).

What is left is predominantly a Southern Ocean genus with about ten species. Several need revision. For example, *T. parva* (Ludwig, 1874) was originally described as having x-shaped ossicles in the external skin layer. However, subsequent specimens with cups or flat "bowls" have also been referred to this species by Panning (1949, 1964), Hernandez (1982) and others. Various authors have also attempted to synonymize *Ocnus kerguelensis* (Theel, 1886), which has multi-layered ossicles, with *T. parva*. Clearly more than one species is involved. The species from Kerguelen, *T. muricata, T. squamata* (Ludwig, 1898), *T. parva, O. kerguelensis* and *O. ekmani* (Ludwig and Heding, 1935), need clear separation.

The generic diagnosis above has been broadened from that of Panning (1964) to include species with lumpy plates or with knobbed buttons. Several species have some minor lumps on the plates (e.g. *T. parva* sensu Panning, *T. macphersonae* Pawson, 1962a, *T. bouvetensis* (Ludwig and Heding, 1935)). However, the plates are never consistently knobbed to the extent of *Ocnus* or *Pseudocnus*. Several species (e.g. *T. bol-*

lonsi (Mortensen, 1925)) have knobbed buttons as a secondary ossicle type. As the primary ossicle type in these cases is smooth plates it seems unnecessary to exclude such species from *Trachythyone*.

The form of the ossicles is the main character distinguishing the species. *T. lechleri* (Lampert, 1885) stands a little apart from the others, having large plates with only very few tiny perforations and some incipiently multi-layered ossicles near the anus. Cups vary from predominantly x-shaped ossicles (e.g. *T. parva*, *T. bollonsi*, *T. peruana* (Semper, 1868)), to well-developed cups with delicate cross and spinous rim (e.g. *T. squamata*, *T. muricata*), to shallow "bowl"-like cups with smaller perforations (e.g. *T. parva* sensu Panning, *T. macphersonae*, *T. mira* (Ludwig and Heding, 1935), *T. nina* (Deichmann, 1930)), to small irregular cups (e.g. *T. crassipeda* Cherbonnier, 1961, *T. bouvetensis*, *T. lechleri*).

The genus *Psolidiella* Mortensen, 1925 has plates, rudimentary cups and scattered dorsal pedicels. It can be distinguished from *Trachythyone* by the presence of a sole and the low incidence of ossicles in the body wall. The monotypic genus *Neopsolidium* Pawson, 1964, with type *N. convergens* (Herouard, 1901), is possibly a synonym of *Trachythyone* or *Psolidiella*. The main ossicle type is smooth, or lumpy, perforated plates, 0.2-0.4 mm long, overlain by small complete cups. The genus is currently placed in the Psolidae, but the form of the ossicles and the lack of a true sole indicates that the species is better placed in the Cucumariidae (Pawson, pers. comm.).

Trachythyone candida sp. nov.

Plates 1c, 5a–f, Figure 5a–c

Psolidium convergens. — Joshua, 1914: 6 [non *Neopsolidium convergens* (Herouard, 1901)].

Psolidium sp. — H.L. Clark, 1946: 415.

Trachythyone sp. — Rowe, 1982: 466, fig. 10.31c. — Rowe and Vail, 1982: 222 (part).

Material examined. Holotype. Victoria, Flinders, Jan 1912, coll. E.C. Joshua, NMV F59200.

Paratypes. Type locality and date, NMV F59201(1); MCZ 1151(slide of whole body mount); Phillip I., Kitty Miller Bay, rocky shallows, just below low tide level, 8 Jan 1986, NMV F54229(1).

Other material (all found in the rocky shallows, 0–2 m, unless otherwise stated).

Victoria, Cape Otway, Moonlight Beach, 11–12 Mar 1975, NMV F57947(2); Deep Sea Cove, 20 Dec 1983, NMV F57945(1); Pebble Point, 18 Feb 1984, NMV F57950(1); Flinders, E of Mushroom Reef, 6 Mar 1982, NMV F54706(1); Harmers Haven, 18 May 1983, NMV F53784(1); Cape Paterson, 29 Mar 1982, NMV F54707(1); 25 Jan 1992, NMV F59228(4); Mallacoota, buried in silt, rocky shallows, 21 Jan 1981, NMV F54701(1).

Tasmania, Bicheno, 7 m, 22 Mar 1988, NMV F59227(1); Eaglehawk Neck, 15 Feb 1991, NMV F59215(3); Tinderbox, below low tide level, 29 May 1974, AM J10863(1 and 5 slides); Southport, Sisters Bay, 8 May 1982, NMV F53792(1).

Description. Up to 8 mm long (tentacles partly extended), 3 mm wide; body predominantly round in transverse section to slightly pentagonal and keeled; body about twice as long as wide; mouth orientated anteriorly; extensible anal cone upturned; distinct modified ventrum, not a sole, rounded not flat; introvert distinct, thin-walled; 10 dendritic tentacles, 2 ventral ones small; body wall fairly thick, 0.4 mm, not rigid, microscopically scaly. Lacking oral valves, about 6 small anal teeth. Large pedicels on ventral radii, extend up to introvert and anus, distinctly smaller near introvert and anus; midventral series an irregular zig-zag; ventrolateral radii with 2 rows, a ventral complete row and an outer lateral incomplete row; up to 35 pedicels on each radius. Small scattered pedicels dorsally and laterally, slightly concentrated on dorsolateral radii into irregular zig-zag series; introvert lacking pedicels; 5 anterior thin extensible pedicles; about 6 extensible anal pedicels. Calcareous ring lacking posterior prolongations; 5 radials with posterior notch, anterior taper and notch; 5 interradials with posterior scallop, pointed anteriorly. Single polian vesicle, left lateral. Dorsal madreporite.

Dorsal body wall ossicles of 3 types: 1) Numerous large, thick, smooth plates, irregularly oval to elongate, up to 0.5 mm long, up to about 40 uniformly distributed perforations, some denticulate at one end with pointed spines, smaller perforations at opposite rounded end. 2) Some knobbed buttons, fairly regular, typically 4 holes, up to 8, typically 0.1 mm long. 3) Shallow cups, 4 times as wide as deep; typically 0.045 mm long; more commonly oval than rectangular; typically 4, up to 8, perforations; rim and cross thin with numerous peg-like spines pointing in all directions; cups form a surface layer in body wall. Ventral body wall with cups and elongate, narrow, slightly lumpy and knobbed, perforated plates, typically 0.25 mm long. Pedicels with endplates, up to 0.23 mm wide, and abundant, oval to elongate, curved, denticulate, often slightly lumpy, perforated plates, typically 0.2 mm long. Tentacles with irregular, curved

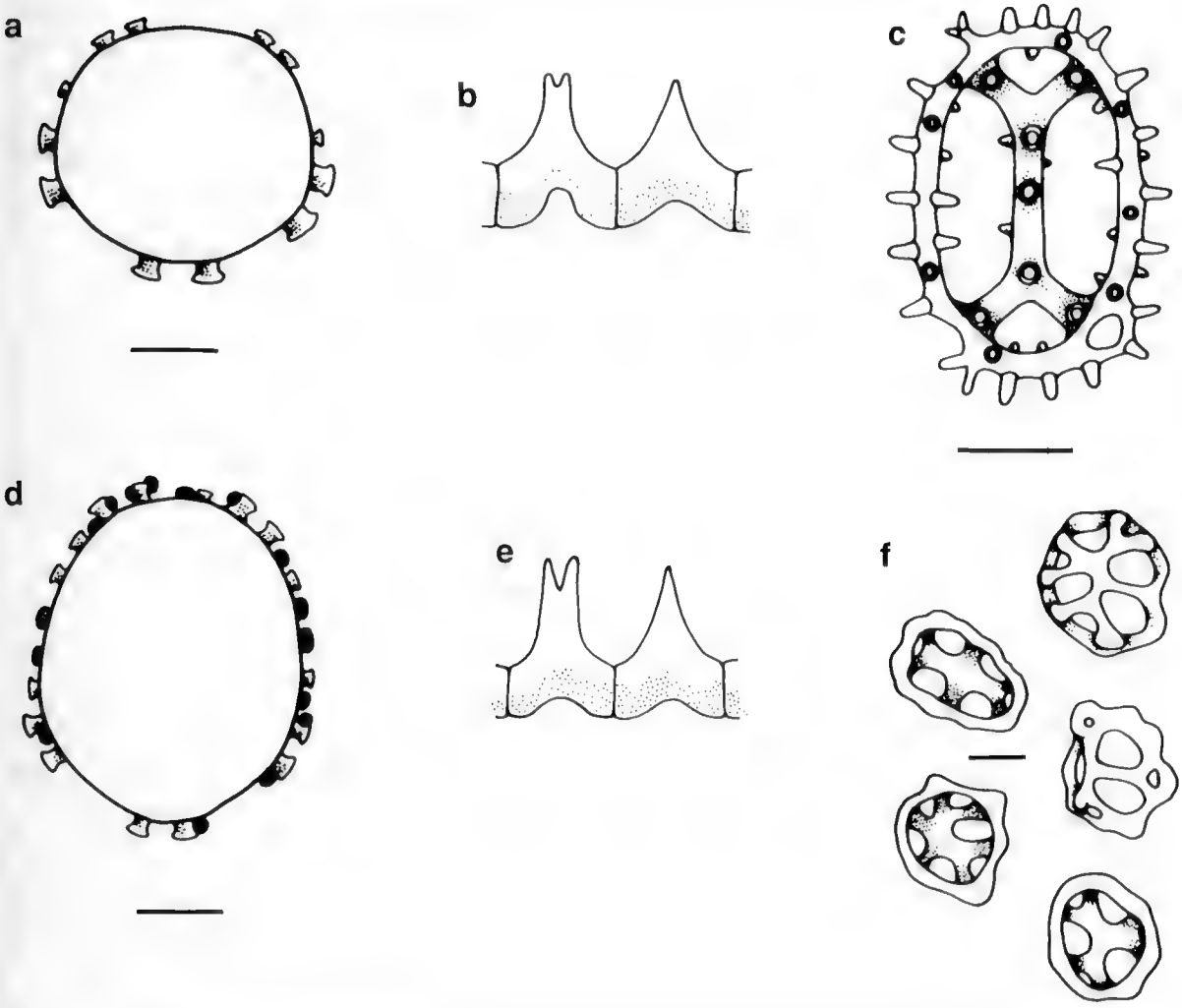


Figure 5. a–c, *Trachythyone candida* sp. nov.: a, transverse section of body, scale bar = 1.0 mm; b, adjacent radial and interradial plates from the calcareous ring; c, top view of a dorsal body wall cup, scale bar = 0.01 mm. d–f, *Trachythyone glebosa* sp. nov.: d, transverse section of body, scale bar = 1.0 mm; e, adjacent radial and interradial plates from the calcareous ring; f, dorsal body wall cups, scale bar = 0.01 mm.

and often bent, often widened centrally, perforated, bar-like ossicles, up to 0.25 mm long; and small, irregular, slightly convex, denticulate, closely perforated plates, typically 0.06 mm wide; lacking rosettes.

Live colour. Body uniform white or pale cream; crystalline; no dark markings; tentacles translucent, may be a few brown markings on trunks.

Reproduction. Sexes separate. Male or female gonad in most specimens (from December to May).

Etymology. From the Latin *candida* (glittering white), in reference to the colour.

Distribution. Western side of Cape Otway to Mallacoota, Victoria, and eastern Tasmania. 0–7 m.

Remarks. Joshua's (1914) specimens, which he identified as *Psolidium convergens,* have been re-examined by us and form the basis of this new species, *T. candida.* The specimens are still in excellent condition and, as the largest available, have been made the types. They do not belong to *Psolidium* Ludwig, 1886 as they do not have a true sole and do possess the medium-sized, non-imbricating, smooth plates in the body wall typical of *Trachythyone.* This species is similar to *Neopsolidium convergens* which, as indicated

above in the generic remarks, should probably be referred to *Trachythyone* or *Psolidiella*.

T. candida can be distinguished from *N. convergens* and all other *Trachythyone* species by the form of the cups, which typically have a complete rim and spines pointing in all directions on both cross and rim.

Specimens have usually been found in silt under rocks in the shallows.

Trachythyone glebosa sp. nov.

Plates 1g, 5g–j, Figure 5d–f

Material examined. Holotype. South Australia, Kangaroo I., Vivonne Bay, N side of Point Ellen, rock and sand, 3–8 m, W. Zeidler and K.L. Gowlett-Holmes, 26 Jan 1989, SAM K1812.

Paratype. Western Australia, W end of Michaelmas I., 35°02.9′S, 118°01.4′E, 15 m, 17 Apr 1986, NMV F59226(1).

Description. Up to 12 mm long (tentacles extended), 3 mm wide and high. Body wall thin; body and pedicels with white lumps of massed ossicles, fewer ventrally; body rounded to slightly pentagonal in transverse section; distinct modified ventrum; mouth orientated anteriorly, anus posteriodorsally; 10 dendritic tentacles, 2 ventral ones distinctly smaller; distinct introvert, lacking pedicels; 5 small scale-like anal teeth; lacking oral valves. Pedicels large; irregular paired rows to zig-zag series on 5 radii; small scattered interradial pedicels dorsally, laterally, lacking on ventral interradii. Pedicels small close to introvert and anus; 5 small ones around anus. Calcareous ring lacking posterior prolongations; 10 plates with tapered anterior projections, radially notched, posterior scallops. Single left lateroventral polian vesicle. Dorsal madreporite.

Dorsal body wall ossicles of 2 types. 1) Abundant large narrow plates, thick, smooth, perforated, rounded tapered ends, up to 0.6 mm long. 2) Cups small, irregular in shape, many with central cross and 4 holes, rim lumpy but lacking distinct knobs or spines, depth variable, most about 0.024 mm long, some larger rectangular ones about 0.04 mm long. Ventral body wall with cups, large narrow perforated plates up to 0.4 mm long. Pedicels with endplates, cups, curved narrow irregular perforated plates up to 0.25 mm long. Tentacles with many small to large, bent, perforated bar-like ossicles, up to 0.22 mm long; thin plates, irregularly oval, convex, denticulate, perforated, typically 0.056 mm wide; abundant rosettes, typically 0.04 mm long.

Colour (preserved). Body colour white to yellow; lumps on body wall and pedicels white; tentacle trunks dark. Dark brown flecking on all interradii of the W.A. specimen.

Reproduction. Immature gonad tubules present in the holotype.

Etymology. From the Latin *glebosa* (lumpy), in reference to the white lumps over the body and pedicels.

Distribution. Michaelmas I., Western Australia to Kangaroo I., South Australia. 3–15 m.

Remarks. Within *Trachythyone*, *T. glebosa* is distinguished by the massing of body wall ossicles into visible white lumps, the elongate shape of the smooth plates, and the very small irregular cups.

Apsolidium gen. nov.

Diagnosis. Body stout with distinct sole and upturned anal and oral ends; 10 dendritic tentacles, ventral 2 smaller; pedicels on periphery and mid-ventral radius of sole, small ones scattered dorsally and laterally. Body wall ossicles knobbed cups, overlying numerous perforated, non-imbricating multi-layered ossicles, up to 1.1 mm long, and lumpy or smooth button-like ossicles. Tentacles with perforated plates, bar-like perforated ossicles; pedicels with perforated plates, endplates. Calcareous ring simple, without posterior prolongations, 10 plates, with tapered anterior projections and posterior scallops.

Type species. Apsolidium handrecki sp. nov.

Etymology. From the Latin *a* (from), in reference to the differences from *Psolidium* (neuter).

Remarks. Apsolidium is similar to the genus *Psolidium* Ludwig, 1886 from the family Psolidae. The psolids are characterized by the presence of a sharply defined sole on the ventral surface and an imbricating armour of large multi-layered ossicles, or scales, covering the dorsal surface. In *Psolidium* the dorsal scales are perforated by the scattered dorsal pedicels. The three species of *Apsolidium* on the other hand have smaller non-imbricating multi-layered ossicles, similar to other cucumariid species such as the *Cucuvitrum* and *Squamocnus* species described in this paper.

Several other cucumariid genera also have well-defined soles. Of these, *Pseudopsolus* Ludwig, 1898, *Neocnus* Cherbonnier, 1972 and *Microchoerus* Gutt, 1990 have reduced ossicles

and virtually no dorsal pedicels. *Psolidiella* Mortensen, 1925 has scattered small plates and rudimentary x-shaped cups. *Neopsolidium* Pawson, 1964, here also regarded as a cucumariid (see *Trachythyone* remarks), differs from *Apsolidium* in having single-layered, often smooth, dorsal plates.

Apsolidium handrecki sp. nov.

Plates 2a, 6a–i, Figure 6a–d

Material examined. Holotype. Victoria, Merricks, rocky shallows, 27 May 1989, M. O'Loughlin, T O'Hara and C. Materia, NMV F54391.

Paratypes. Type locality and date, NMV F54392(1 and 1 juv); 28 Jan 1983, NMV F53765(1); 29 Oct 1980, NMV F53763(2).

Other material. South Australia, Eyre Peninsula, Arno Bay, jetty piles, 2–3 m, 22 Feb 1988, SAM K1815(2).

Western Australia, Trigg I., off *Caulerpa*, 22 Nov 1969, NMV F59225(2).

Description. Up to 20 mm long (tentacles extended), 7 mm wide, 6 mm high; body stout with oral extension and upturned anal cone; body wall thin, densely crystalline; 10 dendritic tentacles, 2 ventral ones distinctly smaller; distinct oval sole, wider than body, margin upturned; distinct narrow introvert, lacking pedicels; anus with 5 teeth. Up to 5 rows of pedicels on periphery of sole, none extending beyond sole to introvert or anus, 2 rows on midventral radius, ventral interradii lacking pedicels; close cover of small pedicels dorsally, laterally, on oral extension and anal cone, used for attaching grit; very extensible small radial pedicels around mouth and anus. Calcareous ring lacking posterior prolongations; 5 radials with anterior projections, sometimes deeply divided, notched posteriorly; 5 interradials with pointed anterior projections, posterior scallops. Madreporite dorsal; single polian vesicle left ventral.

Dorsal body surface ossicles of 4 types. 1) Numerous multi-layered ossicles, non-imbricating, irregularly oval to elongate, up to 0.4 mm long, comprising regularly perforated thick knobbed plates linked together. 2) Some knobbed perforated plates developing secondary layers. 3) Some button-like ossicles, lumpy to smooth, thick, irregular, up to 8 holes, up to 0.2 mm long. 4) A surface layer of fine-rimmed deep cups, typically oval, 4 holes, about as deep as wide; arms of cross thin, branched, terminally knobbed, ends joined to varying degrees to form thin, finely knobbed, sometimes incomplete rim; commonly 0.06 mm long. Sole with cups; abundant elongate plates, frequently narrow, irregular, thick, smooth to knobbed, some bent, up to 15 holes, up to 0.2 mm long; button-like ossicles, fairly regular, typically 4-holed, typically 0.1 mm long; lacking multi-layered ossicles and plates with secondary developments. Pedicels with endplates, 0.24 mm wide; cups; irregular narrow perforated plates, some finely knobbed, bent, curved, convex, up to 0.14 mm long. Tentacles with abundant rosettes, up to 0.08 mm long; bar-like ossicles, small to large, straight or bent, perforated, some widened centrally, up to 0.27 mm long; fine mesh-like plates, irregularly oval to rectangular, convex, denticulate, up to 0.08 mm long.

Live colour. Body grey, created by dense brown-black flecking dorsally; sole pale grey with sparse flecking interradially; rim of sole cream; anal cone dark at apex; tentacle trunks, introvert, oral disc dark brown; tentacle branches pale yellow.

Reproduction. Sexes separate. Holotype and larger paratype (NMV F54392) with mature female gonads; paratype (NMV F53765) with mature male gonad; juvenile (NMV F54392, 5 mm long) with gonad development beginning. Gonoduct attached to dorsal body wall; gonopore between bases of dorsal tentacles.

Etymology. Named in recognition of the contribution by Mr Clarrie Handreck to the fieldwork of the Marine Research Group of Victoria and to the collection of this species.

Distribution. Merricks, Victoria, to Trigg I., SW Western Australia. 0–3 m.

Remarks. At Merricks, Western Port, this species is found adhering to the top or side of rocks in shallow water.

Apsolidium densum sp. nov.

Plates 2b, 7a–h, Figure 6e–g

Material examined. Holotype. Victoria, 10 km NE of Apollo Bay, "Mullet Holes", under rock just below low tide level, 11 Jan 1984, M. O'Loughlin, NMV F54237.

Paratypes. Type locality and date, AM J22753(1); type locality, 7 Jan 1985, NMV F53764(1); Victoria, Flinders, Mushroom Reef, rocky shallows, 22 Jan 1982, NMV F53766(1).

Description. Largest 40 mm long (tentacles withdrawn), 18 mm wide, 12 mm high (mid-body); smaller specimens more elongate; body stout with oral extension and anal cone upturned; body wall thick, up to 1.5 mm, densely crystalline; 10 dendritic tentacles, 2 ventral ones distinctly smaller; distinct oval sole, narrower than

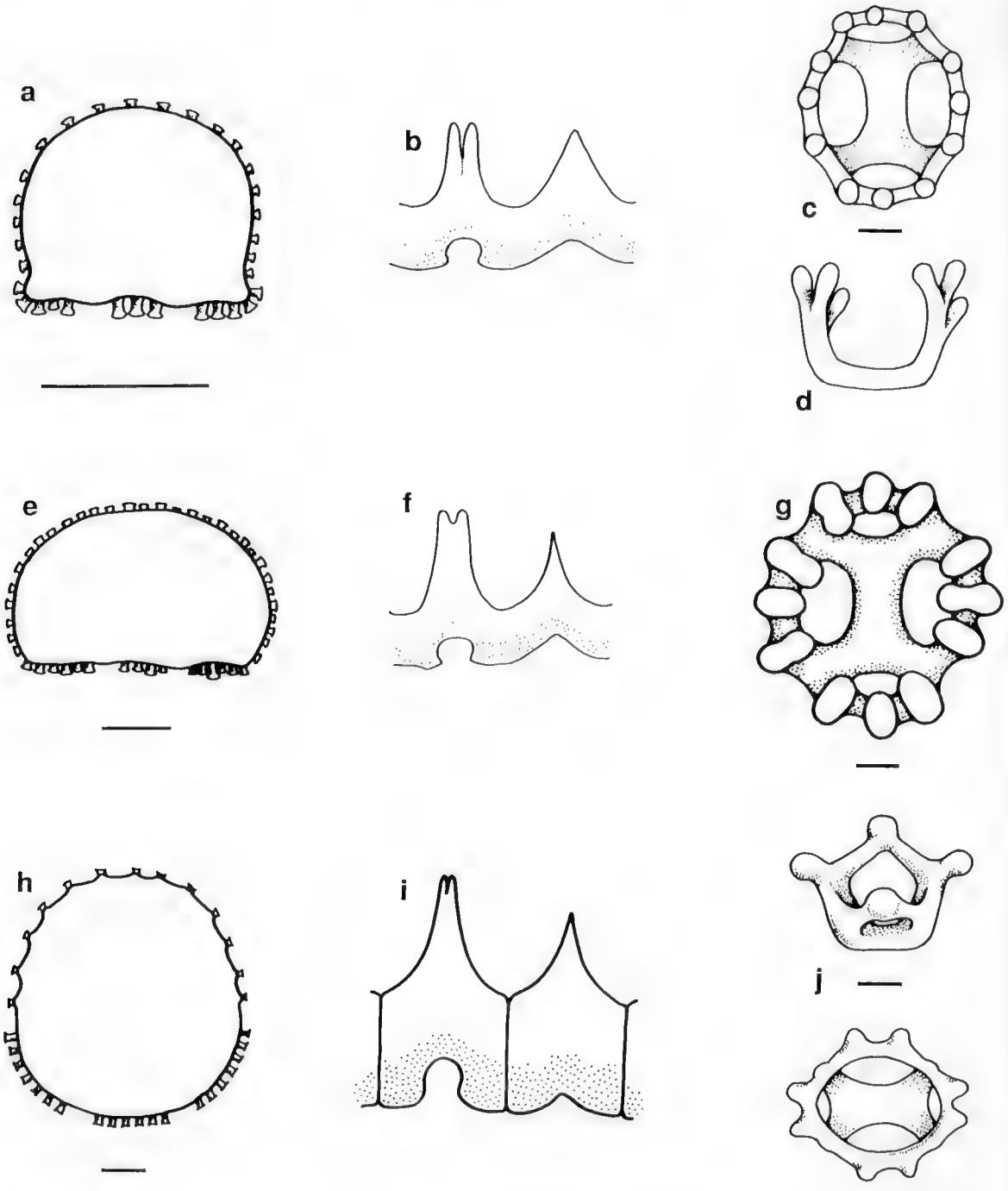


Figure 6. a–d, *Apsolidium handrecki* gen. et sp. nov.: a, transverse section of body, scale bar = 5.0 mm; b, adjacent radial and interradial plates from the calcareous ring; c, top view of a dorsal body wall cup; d, side view of an incomplete cup, scale bar = 0.01 mm.

e–g, *Apsolidium densum* sp. nov.: e, transverse section of body, scale bar = 5.0 mm; f, adjacent radial and interradial plates from the calcareous ring; g, top view of a dorsal body wall cup, scale bar = 0.01 mm.

h–j, *Apsolidium alvei* sp. nov.: h, transverse section of body, scale bar = 5.0 mm; i, adjacent radial and interradial plates from the calcareous ring; j, side and top views of dorsal body wall cups, scale bar = 0.01 mm.

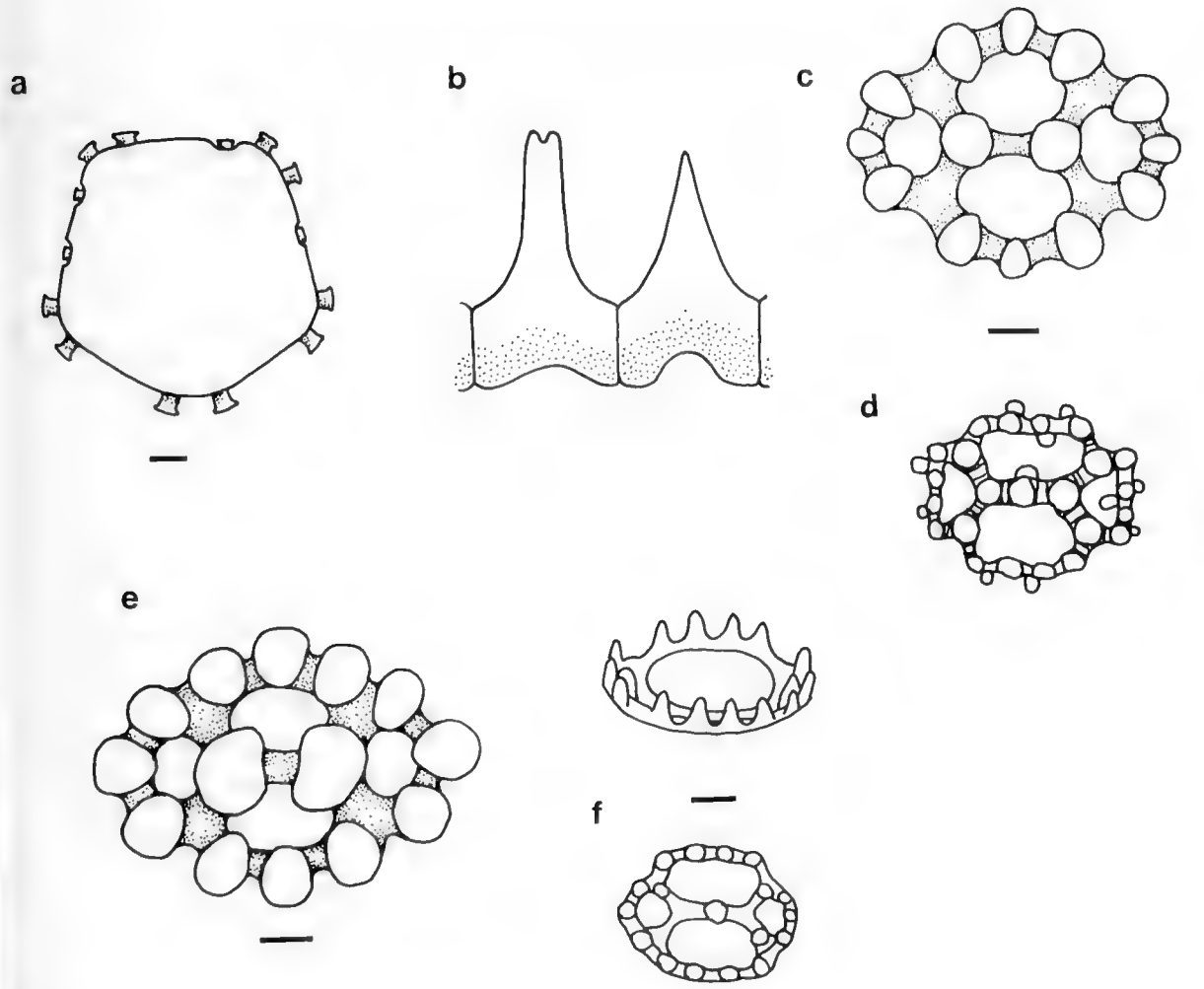


Figure 7. a–d, *Ocnus occiduus* sp. nov.: a, transverse section of body, scale bar = 1.0 mm; b, adjacent radial and interradial plates from the calcareous ring; c, dorsal body wall button; d, top view of a dorsal body wall cup, scale bar = 0.01 mm.

e–f, *Ocnus calcareus* (Dendy, 1896): e, dorsal body wall button; f, side and top views of dorsal body wall cups, scale bar = 0.01 mm.

body. Up to 6 rows of pedicels on periphery of sole, none extending beyond sole to introvert or anus, up to 4 rows on midventral radius, ventral interradii lacking pedicels; close cover of small pedicels dorsally, laterally, on oral body extension and anal cone, used for attaching grit. Calcareous ring lacking posterior prolongations; 5 radials with notched anterior projections, notched posteriorly; 5 interradials, with slightly lower pointed anterior projections, posterior scallops. Single polian vesicle left ventral. Dorsal madreporite.

Dorsal body wall ossicles of 5 types. 1) Massed multi-layered ossicles, irregular, up to 1.1 mm long, comprising regularly perforated thick knobbed plates linked together. 2) Knobbed perforated thick plates with extending knobs, connecting bars, developing secondary layers. 3) Some button-like ossicles, lumpy or smooth, fairly regular, often 4-holed, commonly 0.14 mm long. 4) Some smooth, regularly perforated, somewhat denticulate plates, 0.18 mm long. 5) Knobbed cups, typically oval with 4 holes, rim rarely continuous at corners, about twice as wide as deep, cross and rim thick, only rim heavily knobbed, commonly 0.08 mm long. One large knobbed cup, 0.2 mm long. Sole with cups, smaller multi-layered ossicles. Pedicels with endplates, 0.18 mm wide; cups; bar-like ossicles, thick, straight to bent, sometimes curved, per-

forated, up to 0.34 mm long; perforated plates, irregularly triangular to elongate, marginally denticulate or slightly knobbed, straight or bent, sometimes curved, 0.2 mm long. Tentacles with abundant bar-like ossicles, large to small, irregular, thick, bent, curved, some widened centrally, perforated, up to 0.38 mm long; perforated plates, flat to curved, irregular, up to 0.24 mm long; abundant mesh-like plates, irregularly oval to triangular, convex, denticulate, typically 0.08 mm wide; rosettes up to 0.12 mm long.

Live colour. Body white; some grey flecking dorsally and on oral extension.

Reproduction. Sexes separate. NMV F53766 with male gonad; holotype with female gonad and small eggs.

Etymology. From the Latin *densum* (thick), in reference to the body wall.

Distribution. Apollo Bay and Flinders, Victoria. 0–1 m.

Remarks. A. densum differs from *A. handrecki* in having a very thick body wall; a sole that is narrower than the width of the body; larger ossicles in the body-wall, pedicels and tentacles; more knobs and other secondary developments on plates in the sole; larger, shallower, heavily knobbed cups; and white colour.

Despite intensive searching in the rocky shallows, this species has been found at only two open ocean localities: near Apollo Bay and Flinders, Victoria.

Apsolidium alvei sp. nov.

Plates 1f, 8a–f, Figure 6h–j

Cucumaria squamata. — Joshua and Creed, 1915: 17. [non *Trachythyone squamata* (Ludwig, 1898)].

Cucumaria squamatoides H.L. Clark, 1946: 389. — A.M. Clark, 1966: 345.

'Cucumaria' squamatoides. — Rowe, 1982: 466, fig. 10.31b.

Material examined. Holotype. South Australia, Yorke Peninsula, Marion Bay, washed up on beach, 6 Sep 1978, W Zeidler, SAM K1824.

Paratypes. Type locality and date, SAM K1825(2).

Other material. South Australia, Yorke Peninsula, Marion Bay, in *Posidonia* bed exposed at low tide, 28 Jan 1979, SAM K1821(1); Adelaide, between North Haven and Largs Jetty, 300 m offshore, seagrass, 1 Dec 1980, SAM K1823(1); Glenelg, 10 m, 15 Feb 1959, in *Posidonia*, AM J22638(1); Port Noarlunga, 1960, SAM K1822(1); Encounter Bay, coll. Dr Verco, identified as *Cucumaria squamata* by Joshua and Creed, 1915, SAM K1369(1).

Description. Largest 52 mm long, 33 mm high, 27 mm wide (tentacles slightly extended); body fat, rounded, slightly convex dorsally, deeply convex ventrally; short anteriodorsal and posteriodorsal oral and anal cones; body wall tough, flexible; 10 dendritic tentacles, 2 ventral ones distinctly smaller; distinct short convex sole-like modified ventrum; distinct introvert, lacking pedicels. Lacking oral valves. Ventral radii with 3 short parallel series of small pedicels, widely separated from introvert and anus, about 5 irregular rows on ventrolateral radii, up to 4 rows on midventral radius; small pedicels scattered sparsely and evenly over body, not on introvert or interradii of ventrum. Calcareous ring lacking posterior prolongations; 5 radials with posterior scallop, anterior taper and notch; 5 interradials with posterior scallops, pointed anteriorly. Single elongate polian vesicle, left lateral.

Dorsal body wall ossicles of 3 types. 1) Abundant large plates, thick, smooth, very irregularly oval, closely perforated, often with developing secondary layers and thickenings, up to 1.1 mm long. 2) Button-like ossicles thick, smooth, irregularly quadrilobed to elongate, with up to 8 perforations, typically 0.1 mm long. 3) Deep cups, round to oval, rim knobbed, cruciform centrepiece broad and smooth, 4-holed, some as deep as long, typically 0.045 mm long. Ventral body wall with cups; narrow plates, thin to thick, sometimes lumpy, irregular, up to 14 perforations, typically 0.24 mm long; lacking large plates. Pedicels with endplates, 0.4 mm wide; typical cups; irregular thin, narrow, perforated plates, some curved or bent, some widened centrally, typically 0.24 mm long. Tentacles with small to large, bar-like ossicles, somewhat flat, perforated, often bent with outer widening centrally, up to 0.36 mm long; typical cups; rosettes rare.

Colour (preserved). Body white or pink, very dark orally and anally; tentacle trunks very dark.

Reproduction. Sexes separate; mature gonads present in September; gonopore at inner base of dorsal tentacle pair.

Etymology. From the Latin *alveus* (belly of a ship), in reference to the body form.

Distribution. Yorke Peninsula to Encounter Bay, South Australia. 0–10 m.

Remarks. A. alvei is referred to *Apsolidium*, and not *Trachythyone*, on the basis of the form of the

body wall ossicles and the distribution of pedicels. The body wall plates consistently develop secondary layers and the cups are deep with a knobbed rim, similar to *A. handrecki*. The pedicels are arranged in up to five rows on the ventral radii, and reduced and scattered dorsally, without any signs of concentration on the laterodorsal radii. On the other hand, the secondary developments on the body wall plates are not developed to the extent of *A. handrecki* or *A. densum*. The body form, including the small sole-like ventrum, is also very different from the two other *Apsolidium* species. This correlates with the known habitat of the three species: *A. alvei* prefers seagrass beds while *A. handrecki* and *A. densum* live on rocks. The authors are not satisfied that enough evidence currently exists to assign *A. alvei* its own genus.

The specimen, identified by Joshua and Creed (1915) as *Cucumaria squamata*, has been re-examined by the authors and referred to this species. H.L. Clark (1946) proposed the replacement name *C. squamatoides* for this specimen. However, it was never adequately described by Joshua and Creed, nor examined by H.L. Clark. The name *squamatoides* is therefore a nomen nudum, failing to satisfy ICZN Article 13 as pointed out by A.M. Clark (1966: 345).

A. alvei has been taken predominantly from seagrass (*Posidonia*) beds in Gulf St Vincent.

Ocnus Forbes, 1841

Diagnosis (based on Panning, 1971). Body cucumber-shaped, slightly angular; 10 dendritic tentacles, ventral 2 smaller; pedicels in 1–2 rows on radii. Body wall ossicles cups and small knobbed perforated plates, often with 4 primary holes; pedicels with perforated plates and endplates. Calcareous ring with posterior notches and long tapers anteriorly.

Type species. Ocnus planci (Brandt, 1835).

Remarks. Ocnus has traditionally been a large and heterogenous taxon. Panning (1971) restricted it to only 5 species: *O. planci* (with synonym *O. brunneus* Forbes, 1841) and *O. lacteus* Forbes, 1841 from Europe; and with some doubt: *O. spyridophora* H.L. Clark, 1925 from Hawaii, *O. vicarius* Bell, 1883 and *O. calcareus* (Dendy, 1896) from New Zealand. Unfortunately he did not assign other species, previously referred to *Ocnus*, to other genera. Meanwhile Rowe (1970) established *Aslia* for species with knobbed buttons with four holes only. This distinction is a little arbitrary as buttons with four holes and buttons with more than four holes often occur in the same animal. We believe that it is appropriate to separate species which have multi-layered ossicles. Some of these species have been discussed under *Squamocnus* gen nov.

Within Panning's (1971) *Ocnus* species, *O. calcareus* (and the following new species) differ somewhat from the European species. *O. calcareus* has cups based on a cruciform piece, rather than the three-rayed base of the cups in *O. planci* and *O. lacteus*; and also has some additional large flat plates in the body wall. A future revision could separate the two groups into different genera.

Ocnus occiduus sp. nov.

Plates 1h, 9a–f, Figure 7a–d

Ocnus calcareus. — Rowe, 1982: 446, fig. 10:32a [non *Ocnus calcareus* (Dendy, 1896)].

Material examined. Holotype. South Australia, Ceduna, Cape Vivonne, under rocks, 0–1 m, 14 Jan 1991, M. O'Loughlin, NMV F59212.

Paratypes. Type locality and date, NMV F59213(6).

Other material. Western Australia, Rottnest I., North Point, rocky reef, 30 m, 11 Jan 1991, WAM 254-91(1); Cape Naturaliste, Eagle Bay, Apr 1964, WAM 766-71(1); Bunker Bay, 29 Jan 1975, WAM 425-78(1); Cowaramup Bay, 21 Oct 1989, WAM 880-89(1); Flinders Peninsula, Salmon Holes, 20 Jan 1988, WAM 161-88(1).

South Australia, Nuyts Archipelago, St Francis I., 24 Jan 1982, SAM K1811(9); Franklin Is, 24 Feb 1983, SAM K1810(2); Streaky Bay, Point Westall, 15 Jan 1991, NMV F59219(1); Yorke Peninsula, Gleesons Landing, 8 Nov 1976, SAM K1816(1).

Description. Largest 32 mm long, 10 mm wide, 6 mm high (tentacles withdrawn); body short, wide, low, to elongate or thin, slightly pentagonal in transverse section, frequently twisted; body wall thick, finely crystalline, soft and flexible; mouth orientated anteriorly, anus posteriorly; 10 dendritic tentacles, 2 ventral ones distinctly smaller; distinct thin-walled modified ventrum; distinct introvert, lacking pedicels. Pedicels in paired rows on 5 radii, more regular and distinct ventrally creating distinct modified ventrum; a few small dorsal and lateral interradial pedicels; small pits created where pedicels withdraw into body wall. Calcareous ring lacking posterior prolongations; 5 radials, with posterior scallops, tapered notched anterior projections; 5 interradials, with posterior scallops, pointed anterior projections. Dorsal madreporite. Single polian vesicle, left lateroventral.

Dorsal body wall ossicles of 4 types. 1) Masses of knobbed buttons, fairly regular, typically 4-holed, oval, flat, knobbed centrally and peripherally; typically 14 knobs, 2 central ones not normally larger than peripheral ones, mid-lateral and mid-terminal knobs often smaller than central ones or absent; largest buttons typically 0.09 mm long. 2) Perforated bar-like ossicles, thick, frequently bent or curved, up to 0.29 mm long. 3) Rare large plates, irregularly oval, smooth to lumpy, regular rounded perforations, up to 0.4 mm long. 4) Abundant cups, fairly regular, shallow, about 4 times as long as deep; frequently oval and 4-holed, some rectangular and up to 8-holed; capitate to peg-like spinelets centrally, peripherally, mostly pointing in all directions; cups typically 0.04 mm long. Ventral body wall ossicles as dorsally, but lacking large plates. Pedicels with endplates, 0.22 mm wide; bar-like ossicles, curved or bent, widened centrally, perforated, up to 0.26 mm long; convex, irregular, denticulate, perforated plates, 0.11 mm long. Tentacles with small to large bar-like ossicles, straight and bent, some widened centrally, perforated, up to 0.4 mm long; convex mesh-like plates, irregularly oval to triangular, denticulate, typically 0.06 mm wide; rosettes, 0.07 mm long; some irregular, smooth, slightly convex, perforated plates, 0.11 mm long.

Live colour. Body uniform white, grey on thin ventral surface and sometimes laterally; tentacle trunks dark brown to black; fine tentacle branches pale yellow.

Reproduction. Sexes separate; mature gonads present January and October; gonoduct right dorsolateral; gonad tubules not forked.

Etymology. From the Latin *occiduus* (western), in reference to the western occurrence of this species in southern Australia.

Distribution. Rottnest I., Western Australia to Yorke Peninsula, South Australia. 0–30 m.

Remarks. Three small specimens of *Ocnus calcareus* from New Zealand (AM G1762) were examined for comparison. They conform to the descriptions and figures given by Dendy (1896) and Mortensen (1925). They differ consistently from the Australian species. The largest buttons have two central knobs which are normally significantly larger than the 12 uniform peripheral ones (fig. 7e). The cups are slightly smaller, typically 0.03 mm long; normally four-holed; typically with spinelets pointing vertically to the plane of the cup rim (fig. 7f). The dorsal body wall contains similar bar-like ossicles to *O. occiduus*. The tentacle ossicles are unfortunately extensively eroded, but no rosettes were observed. The body form is more distinctly pentagonal anteriorly. The pedicels emerge from body wall tubercles, and in no instances are withdrawn into pits. These differences are slight, but in the opinion of the authors, significant enough to recognize a new taxon.

O. occiduus is usually found under rocks in the shallows. Despite intensive searching, this species has not been found east of Yorke Peninsula, South Australia.

Thyonidiinae Heding and Panning, 1954

Neocucumis Deichmann, 1944

Diagnosis (based on species currently assigned to the genus). 20 dendritic tentacles, usually in 2 rings, 5 pairs of large interradial tentacles, 5 pairs of small radial tentacles; pedicels in double rows on radii; ossicles tables with round or irregular perforated discs (0.05–0.45 mm diameter) and 2-pillared spires with terminal thorns; pedicel ossicles tables with elongate narrow discs and low 2-pillared spires, endplates, rarely rods, rosettes; calcareous ring simple, without posterior prolongations, 10 plates, radials irregularly rectangular with a large posterior notch and 1-3 smaller anterior notches, interradials at least 0.7 times as high as radials with a median posterior notch and sharp anterior point.

Type species. Cucumaria marioni Von Marenzeller, 1877.

Neocucumis cauda sp. nov.

Plates 2c, 10a–f, Figure 8a–d

Material examined. Holotype. Victoria, 19 km S of Lakes Entrance, 38°04′S, 148°00′E, 28 m, fine sand/shell substrate, 12 Aug 1989, G. Parry on FRV "Sarda", NMV F57952.

Paratype. Type locality and date, NMV F57953(1).

Other material. New South Wales, off Cape Three Points, 76–93 m, "Thetis", Feb 1898, AM J16358(4).

Description. Holotype 12 mm long (tentacles fully withdrawn), 4 mm wide, tail 4 mm long; paratype 9 mm long (tentacles fully withdrawn), 3.5 mm wide, tail 2 mm long; body wall thin; body round in transverse section, with long thin posterior tail; 20 dendritic tentacles, 5 outer pairs large, 5 inner pairs very small; lacking ring of papillae around tentacles. Pedicels in 2 rows

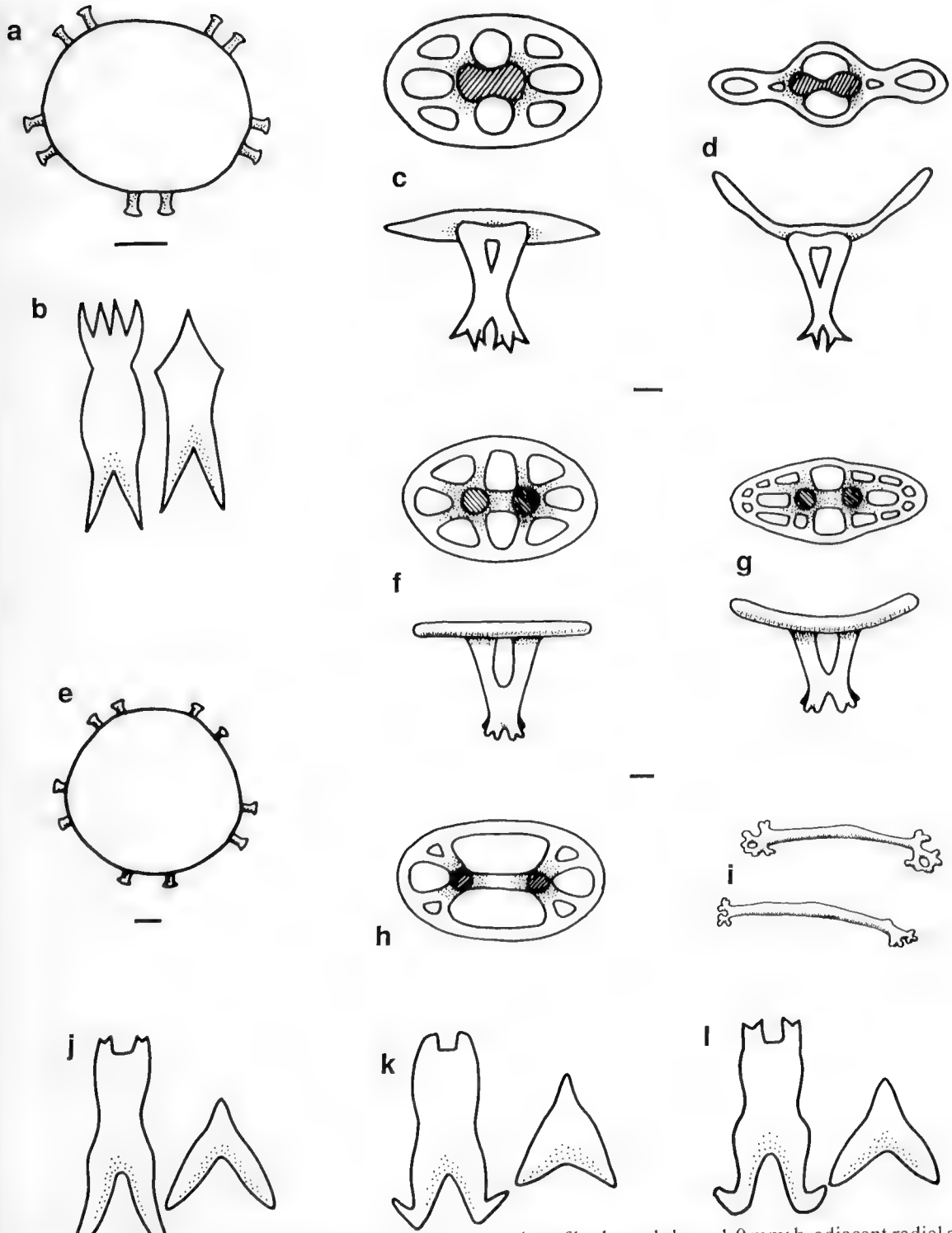


Figure 8. a–d, *Neocucumis cauda* sp. nov.: a, transverse section of body, scale bar = 1.0 mm; b, adjacent radial and interradial plates from the calcareous ring; c, top and side view of dorsal body wall table; d, top and side view of a pedicel table, scale bar = 0.01 mm.

e–l, *Neocucumella fracta* sp. nov.: e, transverse section of body, scale bar = 1.0 mm; f, top and side view of a dorsal body wall table; g, top and side view of a pedicel table; h, top view of an introvert table; i, tentacle rods, scale bar = 0.01 mm; j–l, adjacent radial and interradial plates of the calcareous ring in 3 specimens: j, SAM K1802; k, SAM K1796; l, SAM K1817.

on all 5 radii, up to 80 pedicels on each radius; pedicels slightly more developed ventrally; interradial areas and introvert lacking pedicels; 5 pedicles around anus. Calcareous ring plates slightly separate; 5 radial plates with 4 pointed anterior projections, narrow angular waist, 2 pointed posterior projections; 5 interradial plates with single pointed anterior projection, widened angular shoulders, 2 pointed posterior projections. Dorsal madreporite. Single left lateral polian vesicle.

Body wall ossicles of one type. Abundant closely situated tables; discs rectangular to oval, frequently very irregular, typically 0.09 mm long, typically with 4 large and 4 smaller corner holes, rarely up to 16 holes; spires v-shaped, 2 pillars fused distally, up to 0.04 mm high, typically 4 pairs of pointed terminal spines. Introvert with sparse, narrowly oval, irregular tables, up to 12 holes, up to 0.08 mm long. Pedicels with endplates, 0.13 mm wide; tables with curved discs, frequently very irregular, many very narrow, widened in centre, rounded at ends, up to 0.09 mm long, typically with 4 central holes and small terminal holes, spires similar to body wall tables, shorter, up to 0.03 mm high. Tentacles with numerous thin-walled, elongate, curved plates, up to 0.18 mm long, perforations elongate; numerous very irregular mesh-like plates, partly denticulate, typically 0.06 mm wide.

Reproduction. Holotype and paratype with dorsal female gonad; gonad tubules filled with eggs; up to 10 large tubules, 5 small; tubules elongate, each with a single fork mid-length. Gonoduct on right dorsal body wall.

Colour (preserved). Uniform cream; tentacles yellowish-green; tentacle trunks with transverse reddish-brown markings.

Etymology. From the Latin *cauda* (tail), with reference to the long, thin posterior end of the body.

Distribution. Bass Strait, south of Lakes Entrance, to Cape Three Points, New South Wales. 28–93 m.

Remarks. N. cauda is most similar to *N. watasei* (Ohshima, 1915) from Japan. *N. watasei* also has body wall tables with 4 large and 4 small holes alternating around the table disc, and pedicel tables discs that curve away from the spire (Heding and Panning, 1954). *N. watasei* can be distinguished from *N. cauda* by the presence of a collar of papillae around the tentacles, irregular rod ossicles with perforated ends in the tentacles, and the spire on the body wall tables which is four-columned at the base.

All other species of *Neocucumis* differ in having table ossicles with very irregularly-shaped discs, denticulate discs, or with more or fewer perforations on the disc.

The type specimens of *N. cauda* were dredged from coarse sediments.

Neocucumella Pawson, 1962

Diagnosis (modified from Pawson, 1962b). 20 dendritic tentacles, 5 outer pairs of large interradial tentacles, 5 inner pairs of radial tentacles; pedicels in double rows on radii; body wall ossicles tables with regular oval discs with 4 large and 4 small holes, 0.05–0.10 mm long, spires with 2 pillars and terminal spines; pedicel ossicles endplates, perforated supporting plates and tables, sometimes with curved discs; tentacle ossicles rods with widened, perforated, denticulate ends; calcareous ring simple, without posterior prolongations, 10 plates, radials notched posteriorly and anteriorly, posterior ends divergent, anterior ends truncate, interradials small, inverted V-shaped, less than half as high as radials.

Type species. Pseudocucumis bicolumnatus Dendy and Hindle, 1907.

Remarks. Pawson (1962b) distinguished his new genus *Neocucumella* from *Neocucumis* by the presence of regular eight-holed tables, and rounded ends to the interradial plates in the calcareous ring. Another significant difference is the additional supporting perforated plates which surround the endplate in the pedicels. The collar of papillae surrounding the tentacle crown in *Neocucumella* is also present in at least one *Neocucumis* species, *N. watasei* (Ohshima, 1915).

Of the other cucumariid genera which also possess two-spired tables, *Mensamaria* Clark, 1946 has 30 tentacles and *Amphicyclus* Bell, 1884 has 25.

Neocucumella fracta sp. nov.

Plates 2d, 10g–j, Figure 8e–l

Pseudocucumis bicolumnatus. — Joshua and Creed, 1915: 19.

Mensamaria bicolumnata. — H.L. Clark, 1946: 406.

Neocucumella bicolumnata. — Rowe, 1982: 467 [non *Neocucumella bicolumnata* (Dendy and Hindle, 1907)].

Material examined. Holotype. South Australia, Spencer Gulf, Point Lowly, 33°01′S, 137°48′E, 22 m, Sep 1987, RV "Ngerin", SAM K1797.

Paratypes. Upper Spencer Gulf, E of Monument Hill, 32°50′S, 137°49′E, 17 m, 7–20 Feb 1986, SAM K1817(1); E of Point Lowly, 33°00′S, 137°48′E, 24 m, Sep 1987, SAM K1792(1); Point Lowly, 33°01′S, 137°48′E, 22 m, Aug 1986, SAM K1796(1); 33°01′S, 137°50′E, 12 m, Sep 1987, SAM K1802(1); Fairway Bank, 33°02′S, 137°45′E, 18m, Feb 1987, SAM K1793(2).

Other material. South Australia, no locality or date, coll. Dr Verco, identified as *Pseudocucumis bicolumnata* by Joshua and Creed, 1915, SAM K1373(1); 14 lots from Upper Spencer Gulf, various stations, 32°50′–33°05′S, 137°40′–137°50′E, Feb 1986–Sep 1987, 10–24 m, SAM(5 and 14 'tails').

Victoria, eastern Bass Strait, 38°53.7′S, 147°55.2′E, 71 m, shell/sand, 17 Nov 1981, BSS stn 171, NMV F59214(1).

Description. Body (contracted, tentacles withdrawn) up to 32 mm long, diameter 7.5 mm; body rounded to slightly pentagonal in transverse section; long thin posterior end, frequently detached; lacking sole or modified ventrum; mouth anterior, anus posterior; 20 tentacles, 5 pairs large, 5 inner pairs small. Fur-like collar of numerous fine papillae around the tentacle ring, 0.5 mm long. Lacking oral valves and anal teeth. Pedicels in 2 rows on each radius; pedicels thin, up to 80 in each row; pedicels extend across long introvert; up to 15 small anal pedicels. Calcareous ring lacking posterior prolongations; 5 radial plates with anterior notch, narrowed waist, widened posterior end, wider than anterior end, with large notch; 5 interradials small, inverted V-shaped, with one anterior, 2 posterior blunt pointed corners. Dorsal madreporite. Usually single left lateral elongate tubular polian vesicle (one specimen, SAM K1796, with 4).

Body wall ossicles of one type. Abundant closely-situated tables; discs oval, regular, 8 perforations, typically 0.08 mm long; spires with 2 pillars, slightly tapered and joined distally, 0.04 mm high, typically with 8 blunt spines. Introvert with tables, some smaller and narrowly oval, some with more than 8 perforations, typically 0.06 mm long. Pedicels with endplates, up to 0.2 mm wide; curved supporting plates, elongate, curved, perforated, irregular, sometimes denticulate, typically 0.1 mm long, situated around endplates; tables with discs curved away from spire, narrower than body wall discs, up to 20 perforations, typically 0.08 mm long, spire 0.03 mm high. Tentacles with thin rods, rarely with short branches centrally or terminally, some with up to 4 perforations terminally, some with clumps of small knobs, typically 0.08 mm long.

Colour (preserved). Uniform very pale yellow to white.

Reproduction. Sexes separate; male, female gonad tubules distinguishable in specimens collected in February. Gonad, gonoduct dorsal; gonad tubules not forked.

Etymology. From the Latin *fracta* (fragmentary), with reference to the number of regular posterior body ends collected.

Distribution. Spencer Gulf, South Australia, to eastern Bass Strait. 10–71 m.

Remarks. N. fracta is similar to the only other *Neocucumella* species, *N. bicolumnata* (Dendy and Hindle), known from New Zealand in 7–239 m. *N. bicolumnata*, as described by Dendy and Hindle (1907: 106) and Pawson (1963: 23; 1970: 32), differs in having consistently smaller body wall and tentacle ossicles, tentacle rods with many more terminal perforations, no pedicels on the introvert, and no curved table ossicles in the pedicel walls. The tables typically measure 0.06 mm across and 0.02 mm high. The tentacle rods, which have up to 20 terminal perforations, measure up to 0.06 mm long. *N. bicolumnata* specimens up to 90 mm long have been found, and are usually coloured red or brown in alcohol.

A specimen of *N. bicolumnata* from New Zealand (NZOI station B41, 13 mm long), identified by Pawson (see Pawson, 1970: 32), was examined for comparison. It is consistent with previous descriptions. It differs from *N. fracta* in the smaller size of the body wall tables, 0.06 mm long; larger endplates, up to 0.36 mm wide; absence of pedicel tables with curved discs; and the presence of a pointed "tooth" at the centre of the anterior notch of the radial plates in the calcareous ring. Introvert and tentacle features could not be confirmed because of the condition of the specimen.

The single Bass Strait specimen (NMV F59214) differs from the South Australian *N. fracta* material in having larger tentacle rods, up to 0.15 mm long, and smaller body wall tables, 0.06 mm long. The tables are similar in size to *N. bicolumnata*. The presence of pedicels on the introvert, the form of the tentacle rods, the presence of pedicel tables with irregular curved discs, and the absence of a radial plate "tooth" in

the anterior notch, are all consistent with the *N. fracta* types.

Joshua and Creed (1915) recorded a specimen (SAM K1373) of *N. bicolumnata* collected by Dr Verco from South Australia. This specimen, upon examination, clearly belongs to the present species.

Acknowledgments

We are grateful to Dr Frank Rowe (recently of the Australian Museum) and to Dr David Pawson (Smithsonian Institution) for their encouragement, assistance with the systematics, and English translations of Panning's papers; to Dr C.C. Lu and Ms Suzanne Boyd (Museum of Victoria) for their support and ready assistance with the resources of the Department of Invertebrate Zoology in the Museum of Victoria; to Dr Maria Byrne for her assistance with reproductive biology; to Chris Rowley for his assistance with photography; to Mark Norman and Tania Bardsley for assistance with the figures; to Karen Hazeldene for assistance with labelling the collection; to Margie Atkinson for the drawings of *Neocnus bimarsupiis*; to Mr Wolfgang Zeidler (SAM) and Dr Penny Berents (AM) for providing research facilities and the loan of comparative specimens; to Loisette Marsh (WAM), Lynne Albertson (AM), Lisa Hobbs (SAM), Paul Anderson (NZOI), Alison Green and Elizabeth Turner (TM) also for assisting with the loan of comparative specimens; and to Clarrie Handreck, Christine Materia, Marita Nyhuis, Josephine Stephenson and Keryn Walshe for their significant contribution to the fieldwork.

References

Bell, F.J., 1883. Studies in the Holothuroidea II: Descriptions of new species. *Proceedings of the Zoological Society of London* 1883: 58–62.

Bell, F.J., 1884. Studies in the Holothuroidea III: On *Amphicyclus*, a new genus of dendrochiritous Holothurians, and its bearing on the classification of the family. *Proceedings of the Zoological Society of London* 1884: 253–258, 1 tbl.

Bell, F.J., 1887. Studies in the Holothuroidea VI: Descriptions of new species. *Proceedings of the Zoological Society of London*. 1887: 531–534, pl. 45.

Blainville, H.M.A. de, 1834. *Manuel d'Actinologie et de Xoophytologie*. Paris. 188–197.

Brandt, J.F., 1835. Prodromus descriptionis animalium ab H. Mertensio in orbis terrarum circumnavigatione observatorum *Petropoli* 1: 1–75, 1 pl.

Cannon, L.R.G., and Silver, H., 1987. *Sea cucumbers of northern Australia*. Queensland Museum: Brisbane. pp viii + 60.

Cherbonnier, G., 1961. Deux nouvelles espèces d'holothuries dendrochirotes des cotes Brésiliennes. *Bulletin du Muséum National D'Historie Naturelle, Paris*. (Série 2) 33(6): 611–615, figs 1–2.

Cherbonnier, G., 1972. *Neocnus incubans*, nouveau genre et nouvelle espèce d'holothurie dendrochirote incubatrice de Méditerranée. *Comptes Rendus des Séances de l'Académie des Sciences, Paris*. (Série D) 275(1): 225–227, figs a–q.

Clark, A.M., 1966. Port Phillip Survey, 1957–1963. Echinodermata. *Memoirs of the National Museum of Victoria* 27: 289–384, 10 figs, 4 pls, 1 tbl.

Clark, A.M., and Rowe, F.W.E., 1971. *Monograph of shallow-water Indo-West Pacific echinoderms*. British Museum (Natural History): London. pp vii + 238, 101 text-figs, 31 pls.

Clark, H.L., 1914. The echinoderms of the Western Australian Museum. *Records of the Western Australian Museum* 1: 132–173, pls 17–26.

Clark, H.L., 1925. Echinoderms other than sea stars of the tropical central Pacific. *Bernice P. Bishop Museum Bulletin* 27: 89–112, pls 9–11.

Clark, H.L., 1938. Echinoderms of Australia. An account of collections made in 1929 and 1932. *Memoirs of the Museum of Comparative Zoology, Harvard* 55: viii + 1–596, 63 figs, 28 pls.

Clark, H.L., 1946. The echinoderm fauna of Australia, its composition and origin. *Publications of the Carnegie Institution* 566: iv + 1–567.

Deichmann, E., 1930. The holothurians of the western part of the Atlantic Ocean. *Bulletin of the Museum of Comparative Zoology* 71(3): 43–226, 24 pls.

Deichmann, E., 1941. Holothuroidea collected by the *Valero* III, during the years 1932–1938. Part 1. Dendrochirota. *Allan Hancock Pacific Expeditions* 8: 61–153, text figs 1–6, pls 10–30.

Deichmann, E., 1944. *Urodemas bifurcatum*, a new holothurian from South Africa, with a revision of the genus *Urodemas* Selenka. *Annals and Magazine of Natural History* (Series 11), 11: 731–737, 3 figs.

Dendy, A., 1896. Observations on the holothurians of New Zealand. *Journal of the Linnean Society, London (Zoology)* 26: 22–52, pls 3–7.

Dendy, A., and Hindle, E., 1907. Some additions to our knowledge of the New Zealand holothurians. *Journal of the Linnean Society, London (Zoology)* 30: 95–125, pls 11–14.

Ekman, S., 1918. Results of Dr. E. Mjöberg's Swedish Scientific Expeditions to Australia 1910–1913. XIX Holothuriodea. *Kungliga Svenska Vetenskapsakademiens Handlingar* 58(6): 1–70, 5 pls.

Emson, R.H., and Wilkie, L.C., 1980. Fission and autotomy in echinoderms. *Oceanography and Marine Biology, Annual Review* 18: 155–250, 19 figs, 17 tbls.

Erwe, W., 1913. Holothuroidea. In Michaelsen, W., und Hartmeyer, R. (eds) *Die Fauna Südwest–Australiens* 4: 351–402, fig. 1, pls 5–8.

Forbes, E., 1841. *A history of British starfishes and*

other animals of the class Echinodermata. John van Voorst, London: xx + 267 pp.

Goldfuss, G.A., 1820. *Handbuch der Zoologie.* Nuremberg 1: 1–696, 2 pls.

Grube, A.E., 1840. *Actinen, Echinodermen und Würmer des Adriatischen und Mittlemeeres nach eigenen Sammlungen beschrieben.* Konigsberg: 33–43.

Gutt, J., 1990. New Antarctic holothurians (Echinodermata) 1. Five new species with four new genera of the order Dendrochirotida. *Zoologica Scripta* 19(1): 101–107, 19 figs, 4 tbls.

Heding, S.G., and Panning, A., 1954. Phyllophoridae. Eine Bearbeitung der Polytentaculaten Dendrochiroten Holothurien des Zoologischen Museums in Kopenhagen. *Spolia Zoologica Musei Haunsiensis* 13: 7–209, 102 figs.

Hernandez, D.A., 1982. Holothuroidea des Südwestatlantiks 1. Die *Trachythyone*-Arten. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 79: 251–261, 4 figs, 2 tbls, 2 pls.

Herouard, E., 1901. Note préliminaire sur les holothuries rapportées par l'Expédition Antarctique Belge. *Archives de Zoologie expérimentale et générale, Paris. Notes* 3(9): 39–48.

Hickman, V.V., 1962. Tasmanian sea-cucumbers (Holothuroidea). *Papers and Proceedings of the Royal Society of Tasmania* 96: 49–72, text figs 1–186, pls 1–2.

Hickman, V.V., 1978. Notes on three species of Tasmanian sea-cucumbers including one species that broods its young in the coelome. (Holothurioidea: Phyllophoridae, Caudinidae). *Papers and Proceedings of the Royal Society of Tasmania* 112: 29–37, 44 text-figs, pls 1–2.

Hutton, F.W., 1872. *Catalogue of the Echinodermata of New Zealand, with diagnoses of the species.* James Hughes: Wellington. 20 pp.

Hutton, F.W., 1879 [1878]. Notes on some New Zealand Echinodermata, with descriptions of new species. *Transactions and Proceedings of the New Zealand Institute* 11: 305–8.

Joshua, E.C., 1912. On a new holothurian of the genus *Taeniogyrus* found in Port Phillip Bay. *Proceedings of the Royal Society of Victoria* 25: 79–81, pls 3–4.

Joshua, E.C., 1914. Victorian Holothuroidea with descriptions of new species. *Proceedings of the Royal Society of Victoria* 27: 1–11, pl. 1.

Joshua, E.C., and Creed, E., 1915. South Australian Holothuroidea with descriptions of new species. *Transactions and Proceedings of the Royal Society of South Australia* 39: 16–24, pls 2–4.

Lampert, K., 1885. Die Seewalzen. Holothurioidea. Eine Systematiche Monographie. In Semper, C. (ed.), *Reisen im Archipel der Phillipinen.* Vol. 4, C.W. Kreidel's Verlag: Wiesbaden. 312 pp, 1 pl., 3 figs.

Lesson, R.P., 1830. *Centurie zoologique ou choix d'animaux rares, nouveaux ou imperfaitement connues.* Paris: 1–244, 80 pls.

Ludwig, H., 1874 [1875]. Beiträge zur Kenntniss der Holothurien. *Arbeiten aus dem Zoologisch-Zootomischen Institut in Würzburg* 2: 77–120, pls 6–7.

Ludwig, H., 1886. Die von G. Chierchia auf der Fahrt der Kgl. Ital. Corvette "Vettor Pisani" gesammelten Holothurien. *Zoologische Jahrbucher* 2: 1–36, pls 1–2.

Ludwig, H., 1894. Reports on an exploration off the west coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U.S. Fish Commission Steamer "Albatross" during 1891, Lieut. Commander Z. L. Tanner, U.S.N. commanding. 12, The Holothurioidea. *Memoirs of the Museum of Comparative Zoology, Harvard* 17(3): 1–183, pls 1–19.

Ludwig, H., 1898. Holothurien. *Ergebnisse der Hamburger Magalhaenischen Sammelreise 1892/93,* Band 1. 1–98. L. Friederichsen and Co.: Hamburg.

Ludwig, H., and Heding, S.G., 1935. Die Holothurien der Deutschen Tiefsee-Expedition. 1, Fusslose und Dendrochirote Formen. *Wissenschaftliche Ergebrisse der Deutchen Expedition Tiefsee auf dem Dampher "Valdivia" 1898–9.* 24: 121–214.

Marenzeller, E. Von, 1877. Beiträge zur Holothurienfauna des Mittlemeeres. *Verhandlungen (K.-K.) Zoologisch-botanische Gesellschaft, Wein.* 27: 117–122, pl. V.

Marine Research Group of Victoria, 1984. *Coastal invertebrates of Victoria. An atlas of selected species.* Marine Research Group in association with the Museum of Victoria: Melbourne. 168 pp, 13 figs, 1 tbl.

Materia, C.J., Monagle, J.F., and O'Loughlin, P.M., 1991. Seasonal coelomic brooding in southern Australian cucumariids (Echinodermata, Holothurioidea). Pp. 301–307, 5 figs, 5 tbls in: Yanagisawa, Yasumasu, Oguro, Suzuki and Motokawa (eds). *Biology of Echinodermata.* Balkema: Rotterdam.

Mortensen, T., 1925. Echinoderms of New Zealand and the Auckland–Campbell Islands. III–V. Asteroidea, Holothurioidea and Crinoidea. *Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kobenhavn* 79: 261–420, text figs 1–70, pls 12–15.

Ohshima, 1915. Report on the holothurians collected by the United States Fisheries Steamer "Albatross" in the Northwestern Pacific during the summer of 1906. *Proceedings of the United States National Museum* 48: 213–291, pls 8–11.

Oken, L., 1815. *Lehrbuch der Naturgeschichte.* Part 3. Zoologie. Leipzig and Jena. pp xxviii + 850 + xviii.

O'Loughlin, P.M., 1991. Brooding and fission in shallow water echinoderms of southern Australia. Pp. 223–228, 5 figs, 1 tbl. in: Yanagisawa, Yasumasu, Oguro, Suzuki and Motokawa (eds). *Biology of Echinodermata.* Balkema: Rotterdam.

Pallas, P.S., 1766. *Miscellanea Zoologica.* Hagaee:

152–156, pl.xi, figs 10–12.

Panning, A., 1949. Versuch einer Neuordnung der Familie Cucumariidae (Holothurioidea: Dendrochirota). *Zoologische Jahrbucher, Abteilung fur Systematik, Okologie und Geographie der Tiere* 78(4): 404–470, 62 figs.

Panning, A., 1962. Bermerkungen über die Holothurien-Familie Cucumariidae (Ordnung Dendrochirota). 3. Teil. Die Gattung *Pseudocnus* Panning, 1949. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 60: 57–80, figs 1–20.

Panning, A., 1964. Bermerkungen über die Holothurien-Familie Cucumariidae (Ordnung Dendrochirota). 4. Teil. Die Gattungen *Stereoderma, Staurothyone*, und *Trachythyone. Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* (Kosswig-Festschrift) 61: 159–74, figs 1–10.

Panning, A., 1966. Bermerkungen über die Holothurien-Familie Cucumariidae (Ordnung Dendrochirota). 5. Teil. Die Gattungen *Heterothyone* Pannning, 1949 und *Leptopentacta* H.L. Clark, 1938. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 63: 51–69, 8 text-figs, 4 pls.

Panning, A., 1971. Bermerkungen über die Holothurien-Familie Cucumariidae (Ordnung Dendrochirota). 6. Teil. Die Gattungen um *Ocnus* Forbes, 1841 und um *Pentacta* Goldfuss, 1820. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 67: 29–51, text-figs 1–5, pl. 3.

Pawson, D.L., 1962a. A new sea cucumber from Macquarie Island. *Transactions of the Royal Society of New Zealand, Zoology* 2(7): 47–48, pl. 1.

Pawson, D.L., 1962b. A new phyllophorid genus in the Holothuroidea. *Transactions of the Royal Society of New Zealand, Zoology* 2(11): 65–67, figs 1–2.

Pawson, D.L., 1963. The holothurian fauna of Cook Strait, New Zealand. *Zoology Publications from Victoria University of Wellington* 36: 1–38, 7 pls.

Pawson, D.L., 1964. The Holothuroidea collected by the Royal Society Expedition to southern Chile, 1958–59. *Pacific Science* 18(4): 453–470, figs 1–3.

Pawson, D.L., 1966. Evolution and phylogeny of the Holothuroidea. Pp. U641–U646 in: Moore, R.C. (ed), *Treatise on Invertebrate Paleontology*, Part U(2), Echinozoa and Asterozoa. Geological Society of America and The University of Kansas.

Pawson, D.L., 1970. The marine fauna of New Zealand: sea cucumbers (Echinodermata: Holothuroidea). *New Zealand Oceanographic Institute Memoir* 52: 1–69, 10 text-figs, 2 pls.

Pawson, D.L., 1983. *Ocnus sacculus* new species (Echinodermata: Holothuroidea) a brood protecting holothurian from south-eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research* 17: 227–230, 2 figs.

Pawson, D.L., and Fell, H.B., 1965. A revised classification of the dendrochirote holothurians. *Breviora* 214: 1–7.

Quoy, J.R.C., and Gaimard, J.P., 1833. *Voyage de découvertes de l'"Astrolabe". Zoologie, Zoophytes.* Paris: 1–390, 26 pls.

Rowe, F.W.E., 1970. A note on the British species of cucumarians, involving the erection of two new nominal genera. *Journal of the Marine Biological Association of the United Kingdom* 50: 683–687.

Rowe, F.W.E., 1976. Restriction of the chiridotid genus *Trochodota* Ludwig (1891) (Holothurioidea: Apodida), with the description of a new species from South Australia. *Transactions of the Royal Society of South Australia* 100(4): 203–206, figs 1–4, tbl 1.

Rowe, F.W.E., 1982. Sea-cucumbers (class Holothurioidea). Pp. 454–474, figs 10:26–10:37, pls 29–32 in: Shepherd, S.A. and Thomas, I.M. (eds), *Marine invertebrates of southern Australia. Part 1.* Government Printer: Adelaide.

Rowe, F.W.E. and Vail, L.L., 1982. The distribution of Tasmanian echinoderms in relation to southern Australian biogeographic provinces. Pp. 219–225, 1 fig. in: Lawrence J. M. (ed), *Echinoderms: Proceedings of the International Conference, Tampa Bay.* Balkema: Rotterdam.

Rowe, F.W.E., and Pawson, D.L., 1985. *Loisettea amphictena*, new genus, new species, from the sublittoral of northwestern Australia (Echinodermata: Holothuria). *Proceedings of the Biological Society of Washington* 98(3): 672–677, figs 1–3, tbl 1.

Selenka, E., 1867. Beiträge zur Anatomie und Systematik der Holothurien. *Zeitschr fur wissenschaftliche Zoologie, Leipzig* 17: 291–374, pls 17–20.

Semper, C., 1868. Holothurien. *Reisen im Archipel der Philippinen*, Teil 2 Wissenschaftliche Resultate, Leipzig. Bd 1: 1–288, pls 1–40.

Semper, C., 1869. Die Holothurien Ostafricas. In: Decken, C.C. von der (ed.), *Reisen in Ost Africa in den Jahren 1859–1865.* Leipzig and Heidelburg 3(1): 119–122, 1 pl.

Studer, T., 1876. Über Echinodermen aus dem antarkischen Meere und zwei neue Seeigel von den Papua-Inseln, gesammelt auf der Reise SMS "Gazelle" um die Erde. *Monatsberichte d.k. Preussiche Akademie der Wissenschaften. Berlin*: 452–65.

Thandar, A.S., 1985. A new southern African genus in the holothurian family Cucumariidae (Echinodermata: Holothuroidea) with the recognition of two subspecies in *Cucumaria frauenfeldi* Ludwig. *South African Journal of Zoology*. 20(3): 109–114, 4 figs, 1 tbl.

Thandar, A.S., 1986. A new genus and species of a dendrochirotid holothurian from South Africa. *Zoological Society of London* (A) 210: 483–488, 1 fig.

Thandar, A.S., 1987. The status of some southern African nominal species of *Cucumaria* (s.e.)

referable to a new genus and their ecological isolation. *South African Journal of Zoology* 22(4): 287–296, 7 figs.

Theel, H., 1886. Report on the Holothurioidea. Part 2. *Reports on the Scientific Results of the Voyage of HMS "Challenger" 1873–76.* Zoology 39: 1–290, 16 pls.

Troschel, F.H., 1846. Neue Holothurien-Gattungen. *Archiv fur Naturgeschichte, Berlin* 12(1): 60–66.

Explanation of Plates

Plate 1 Figures a–h, ventrolateral views of holotypes, scale bar = 5 mm: a, *Pentocnus bursatus* gen. et sp. nov., NMV F57549, 6 mm long; b, *Cucuvitrum rowei* gen. et sp. nov., NMV F57356, 9 mm long; c, *Neocnus bimarsupiis* sp. nov., NMV F54238, 5 mm long; d, *Squamocnus aureoruber* gen. et sp. nov., NMV F54244, 11 mm long; e, *Trachythyone candida* sp. nov., NMV F59200, 8 mm long; f, *Apsolidium alvei* sp. nov., SAM K1824, 54 mm long; g, *Trachythyone glebosa* sp. nov., SAM K1812, 12 mm long; h, *Ocnus occiduus* sp. nov., NMV F59212, 23 mm long.

Plate 2 Figures a–d, ventrolateral views of holotypes, scale bar = 5 mm: a, *Apsolidium handrecki* gen. et sp. nov., NMV F54391, 14 mm long; b, *Apsolidium densum* sp. nov., NMV F54237, 35 mm long; c, *Neocucumis cauda* sp. nov., NMV F57952, 12 mm long; d, *Neocucumella fracta* sp. nov., SAM K1797, 25 mm long.

Figures e–h, ossicles, scale bar = 0.1 mm: e–g *Pentocnus bursatus* gen. et sp. nov.: e, body wall perforated plate, NMV F59207; f, body wall perforated plates, type series; g, tentacle ossicles, mainly irregular rods, type series; h, *Neocnus bimarsupiis* sp. nov., tentacle rods, NMV F54387.

Plate 3 Figures a–g, ossicles of *Cucuvitrum rowei* gen. et sp. nov., scale bar = 0.1 mm: a, ventral body wall perforated plate with projecting knobs and connecting bars, holotype; b, dorsal body wall multi-layered ossicle, AM J10883; c, dorsal body wall knobbed perforated plates, NMV F59221; d, dorsal body wall multi-layered ossicles and knobbed plates, NMV F59221; e, dorsal body wall knobbed button-like ossicles, NMV F59221; f, ventral pedicel bar-like ossicles, holotype; g, tentacle ossicles, NMV F59221.

Plate 4 Figures a–h, ossicles of *Squamocnus aureoruber* gen. et sp. nov., scale bar = 0.1 mm: a, ventral body wall perforated plates with secondary developments, NMV F54704; b, dorsal body wall multi-layered ossicle, NMV F53793; c, dorsal body wall spinous cups, larger 0.04 mm long, NMV F53793; d, dorsal body wall knobbed button, cups, and part of a multi-layered ossicle, NMV F59220; e, ventral body wall and pedicel non-spinous cups, and flat and bar-like ossicles, NMV F54704; f, dorsal body wall knobbed button, NMV F53793; g, ventral pedicel flat and bar-like ossicles, NMV F59220; h, tentacle bar-like ossicles, NMV F59220.

Plate 5 Figures a–f, ossicles of *Trachythyone candida* sp. nov., scale-bar = 0.1 mm: a-b, dorsal body wall perforated plates, some denticulate, NMV F59215; c, ventral body wall cup, 0.05 mm long, holotype; d, ventral body wall cups, NMV F54701; e, ventral pedicel perforated plate, NMV F54701; f, tentacle ossicles, NMV F59215.

Figures g–j, ossicles of *Trachythyone glebosa* sp. nov., holotype, scale bar = 0.1 mm: g, dorsal lump perforated plate; h, dorsal lump irregular cups; i, ventral pedicel endplate and curved narrow perforated plates; j, tentacle bent bar-like ossicle and rosettes.

Plate 6 Figures a–i, ossicles of *Apsolidium handrecki* gen. et sp. nov., type series, scale bar = 0.1 mm: a, sole cups and button-like ossicles; b, sole lumpy and smooth button-like ossicles, cups, and curved pedicel plate; c, part of dorsal body wall multi-layered ossicle; d, side view of dorsal body wall developing cup, 0.05 mm wide; e, end view of dorsal body wall cup, 0.05 mm wide; f, ventral pedicel narrow perforated plates; g, ventral pedicel endplate; h, tentacle bar-like ossicles and mesh-like plate; i, tentacle rosettes.

Plate 7 Figures a–h, ossicles of *Apsolidium densum* sp. nov., scale bar = 0.1 mm: a, dorsal body wall multi-layered ossicle, NMV F53766; b, dorsal body wall large knobbed cup, NMV F53766; c, sole cups, NMV F53764; d, dorsal body wall smooth perforated plate, NMV F53766; e, dorsal body wall lumpy and smooth button-like ossicles, NMV F53764; f, tentacle rosette, NMV F53764; g, pedicel bar-like ossicles, NMV F53764; h, tentacle bar-like ossicles and mesh-like plates, NMV F53764.

Plate 8 Figures a–f, ossicles of *Apsolidium alvei* sp. n, holotype, scale bar = 0.1 mm: a, dorsal body wall large plate, button-like ossicles, and cups; b, ventral body wall narrow plates and cup; c, ventral body wall cups; d, ventral body wall

cups in side, end and ventral view; e, ventral pedicel endplate, thin perforated pedicel plates, and thick narrow body wall plates; f, tentacle bar-like ossicles.

Plate 9 Figures a–f, ossicles of *Ocnus occiduus* sp. nov., scale bar = 0.1 mm: a, dorsal body wall buttons, SAM K1811; b, dorsal body wall cups, SAM K1811; c, dorsal body wall perforated plate, SAM K1811; d, dorsal body wall bent bar-like ossicles, SAM K1811; e, pedicel bar-like ossicles, SAM K1816; f, tentacle bar-like ossicles, mesh-like plates, rosette and button, SAM K1816.

Plate 10 Figures a–f, ossicles of *Neocucumis cauda* sp. nov., type series, scale bar = 0.1 mm: a-c body wall and pedicel tables; d, introvert tables; e-f, tentacle plates.

Figures g–j, ossicles of *Neocucumella fracta* sp. nov., scale bar = 0.1 mm: g–h, body wall tables, holotype; i, pedicel tables, holotype; j, tentacle rods, SAM K1373.

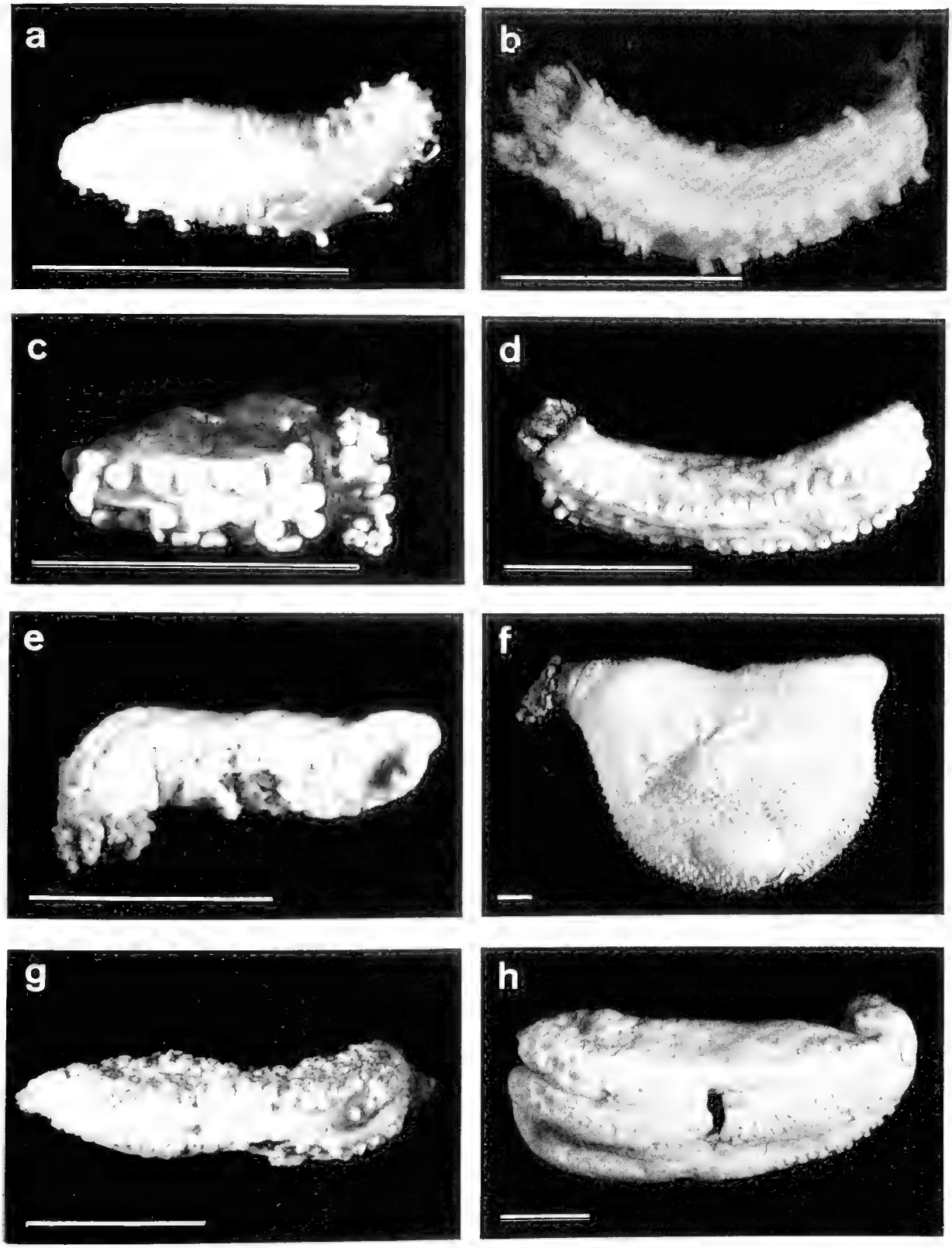


PLATE 1

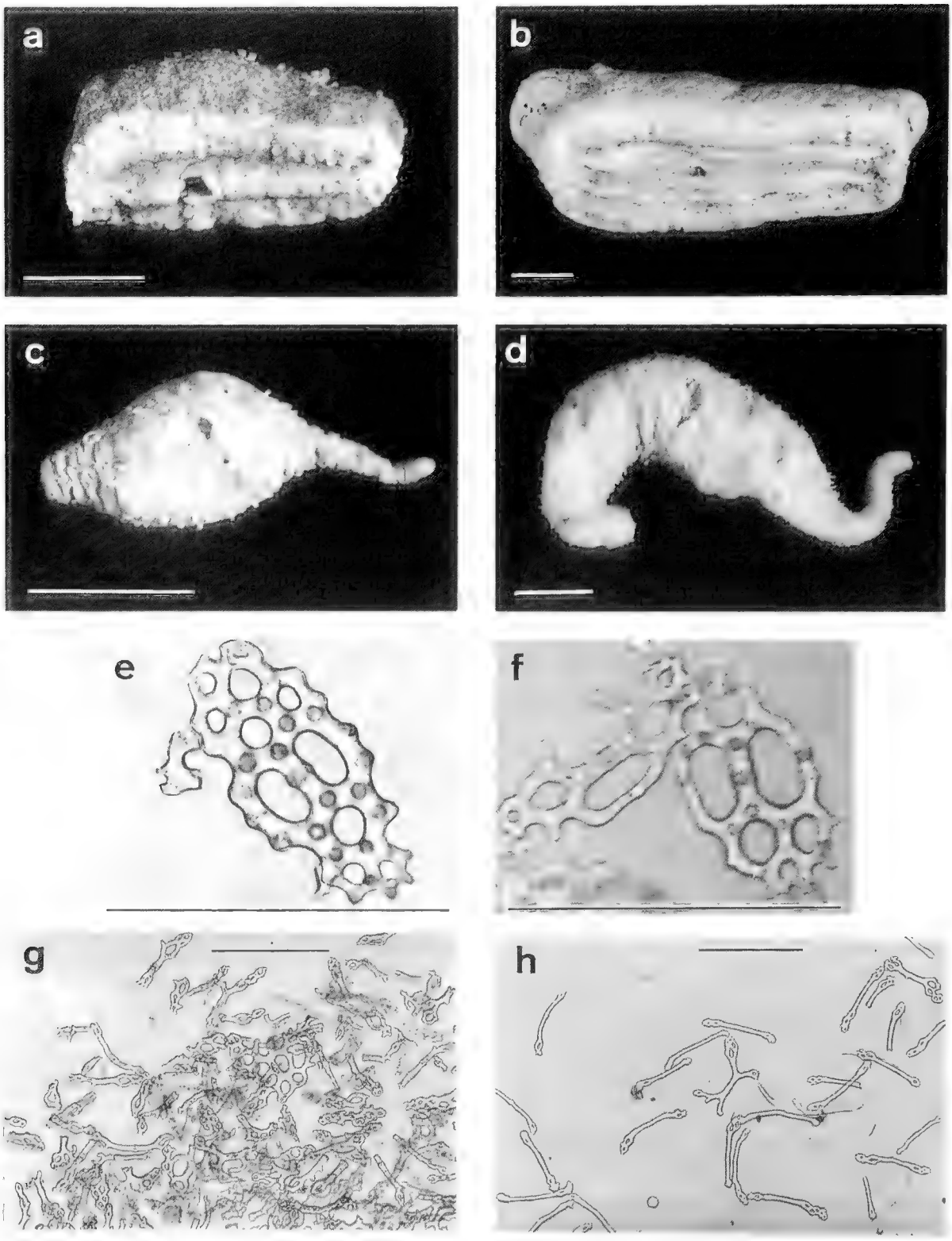


PLATE 2

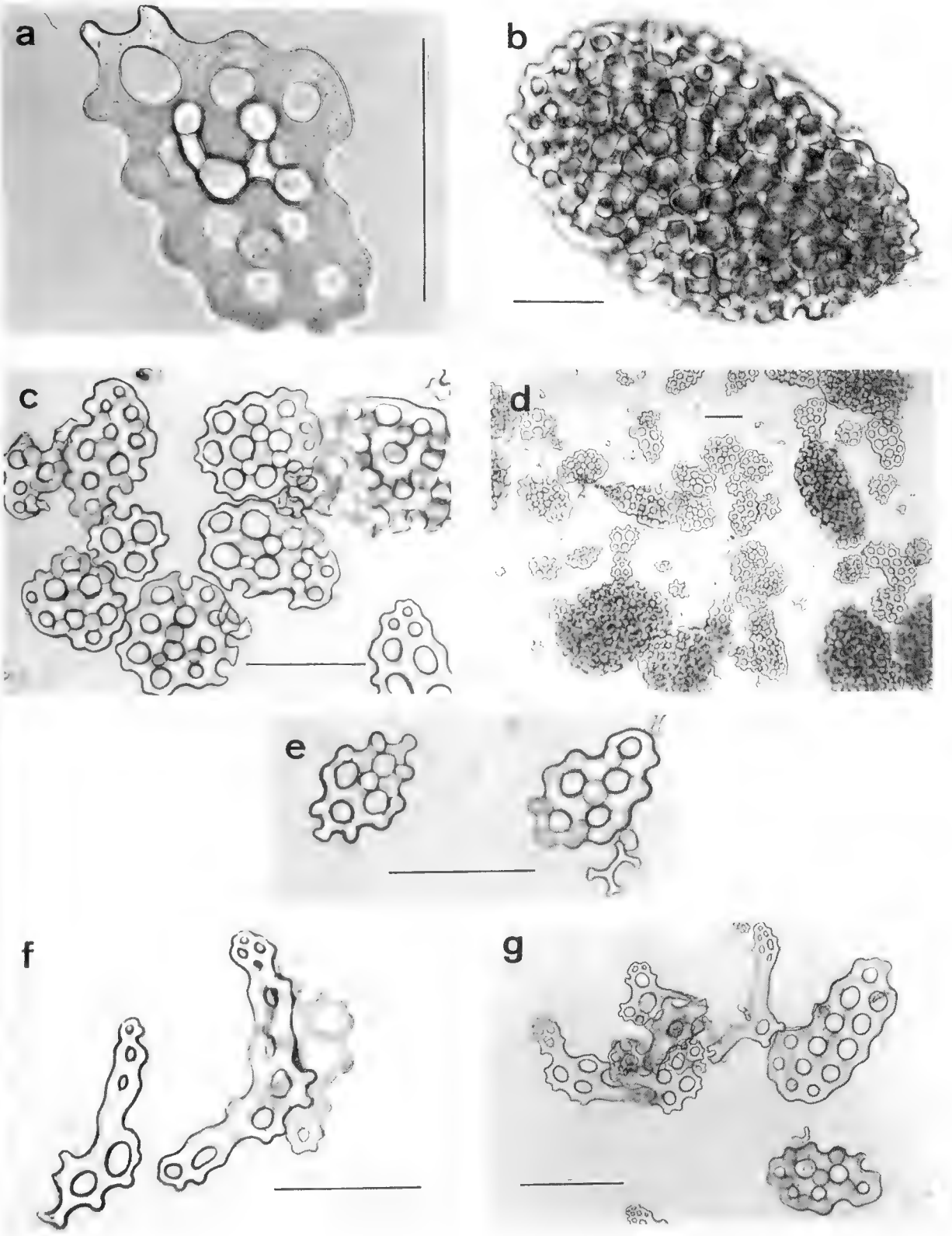


PLATE 3

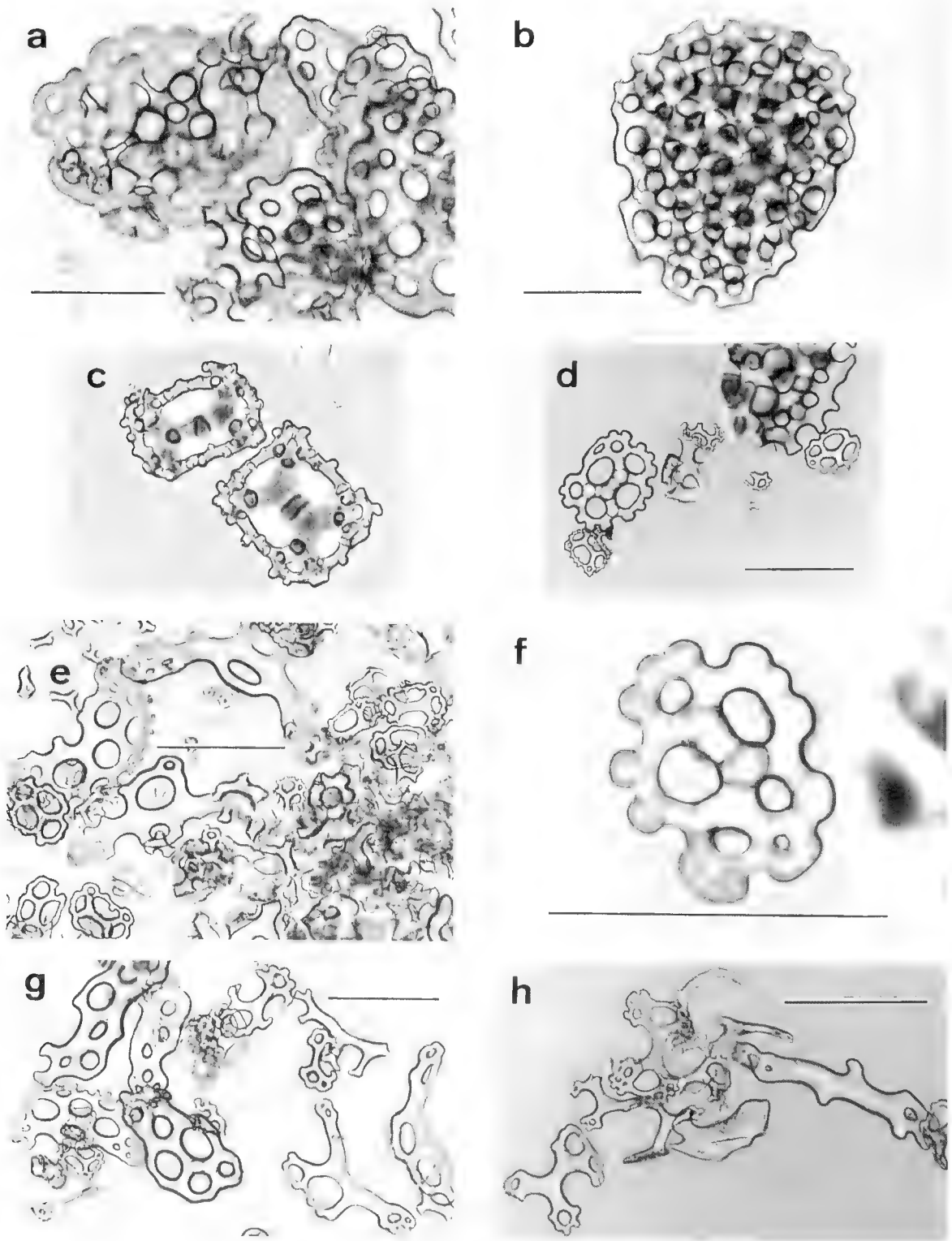


PLATE 4

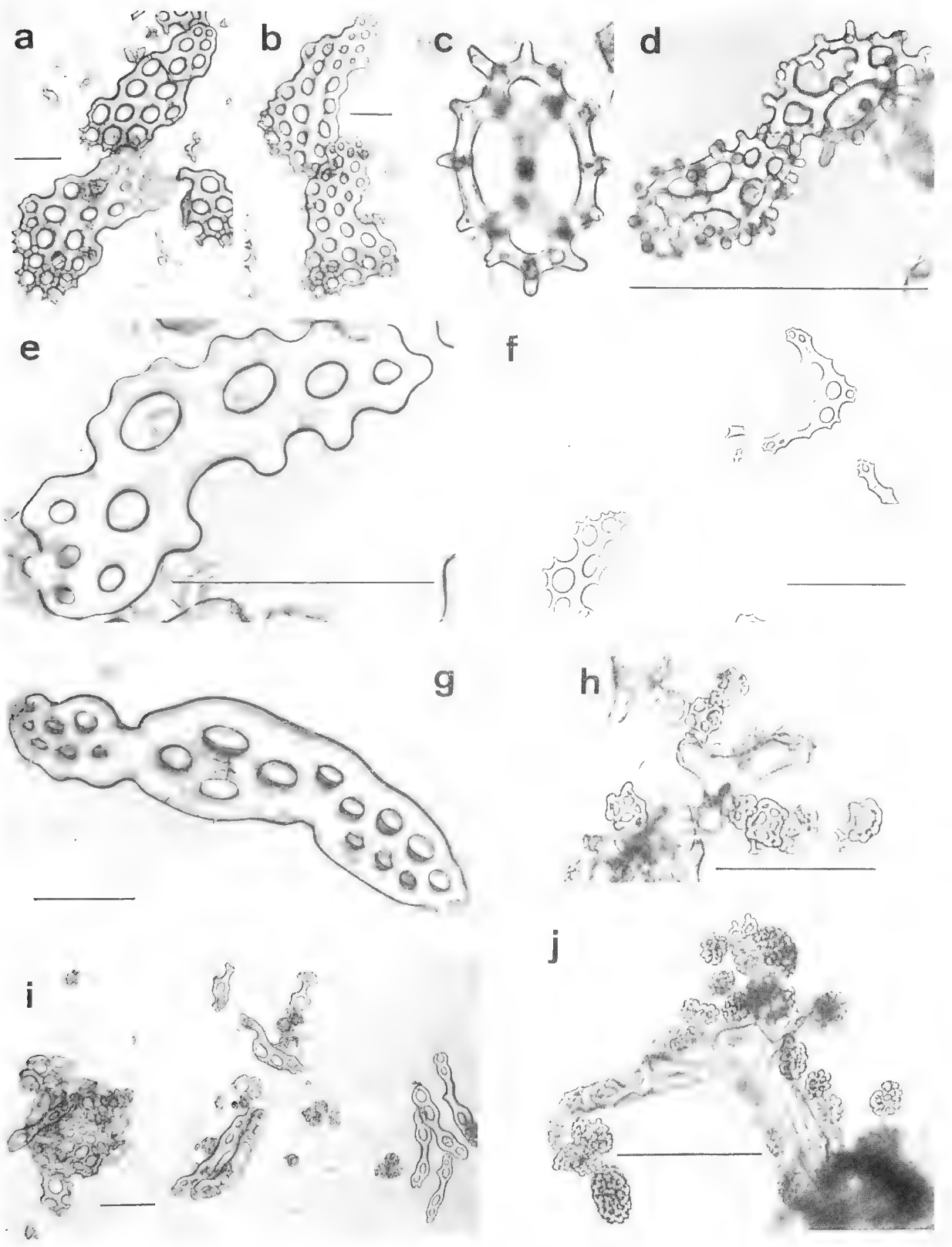


PLATE 5

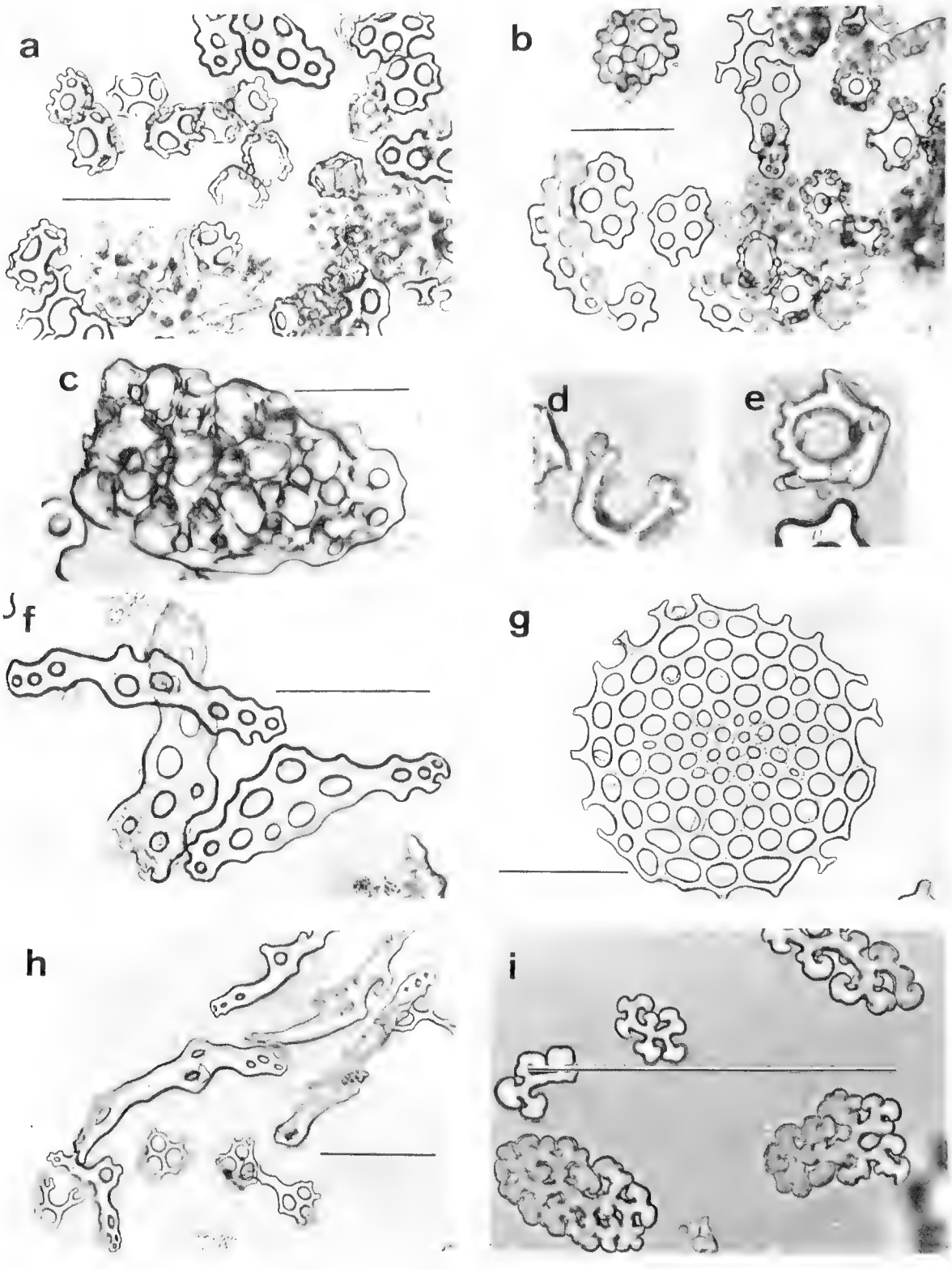


PLATE 6

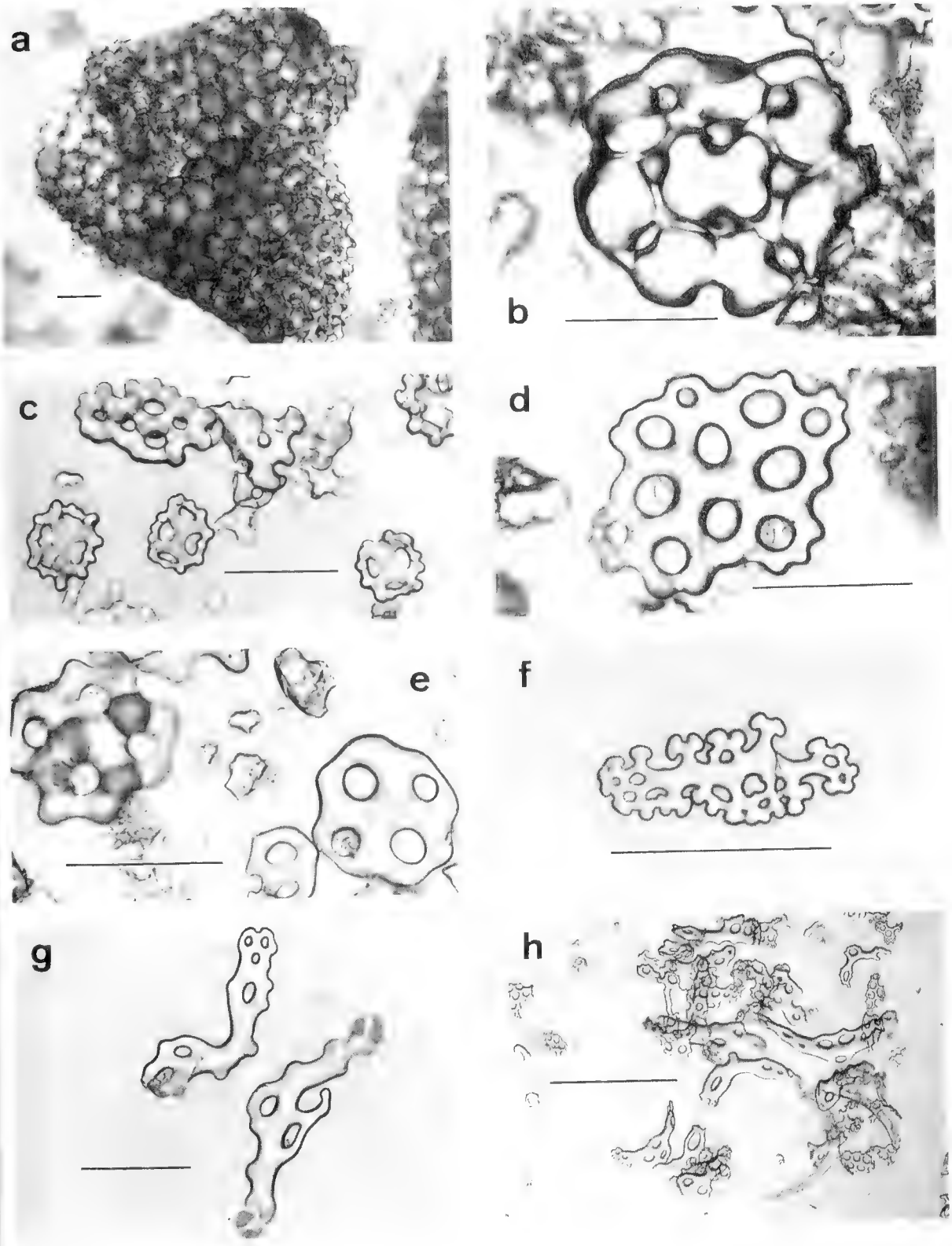


PLATE 7

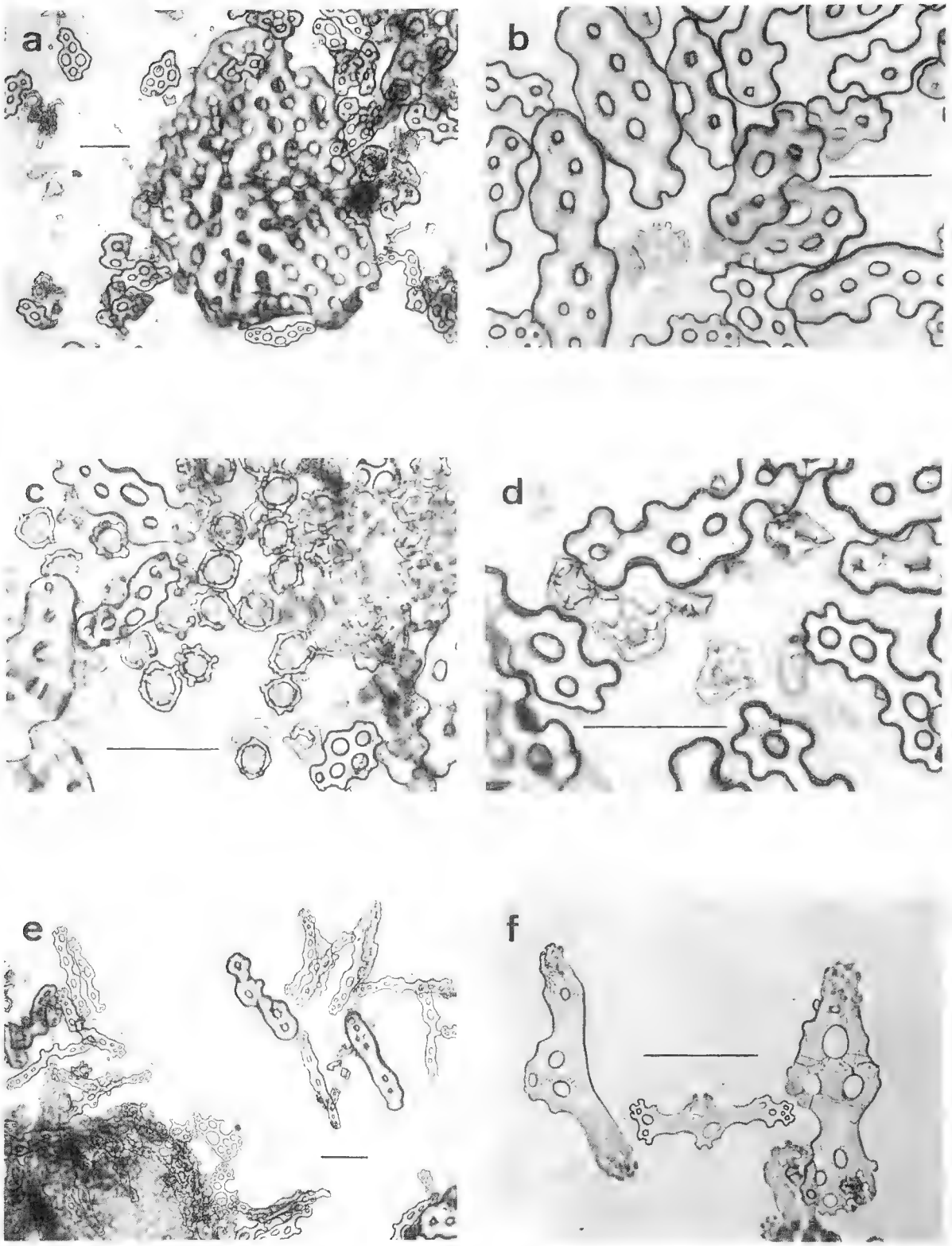


PLATE 8

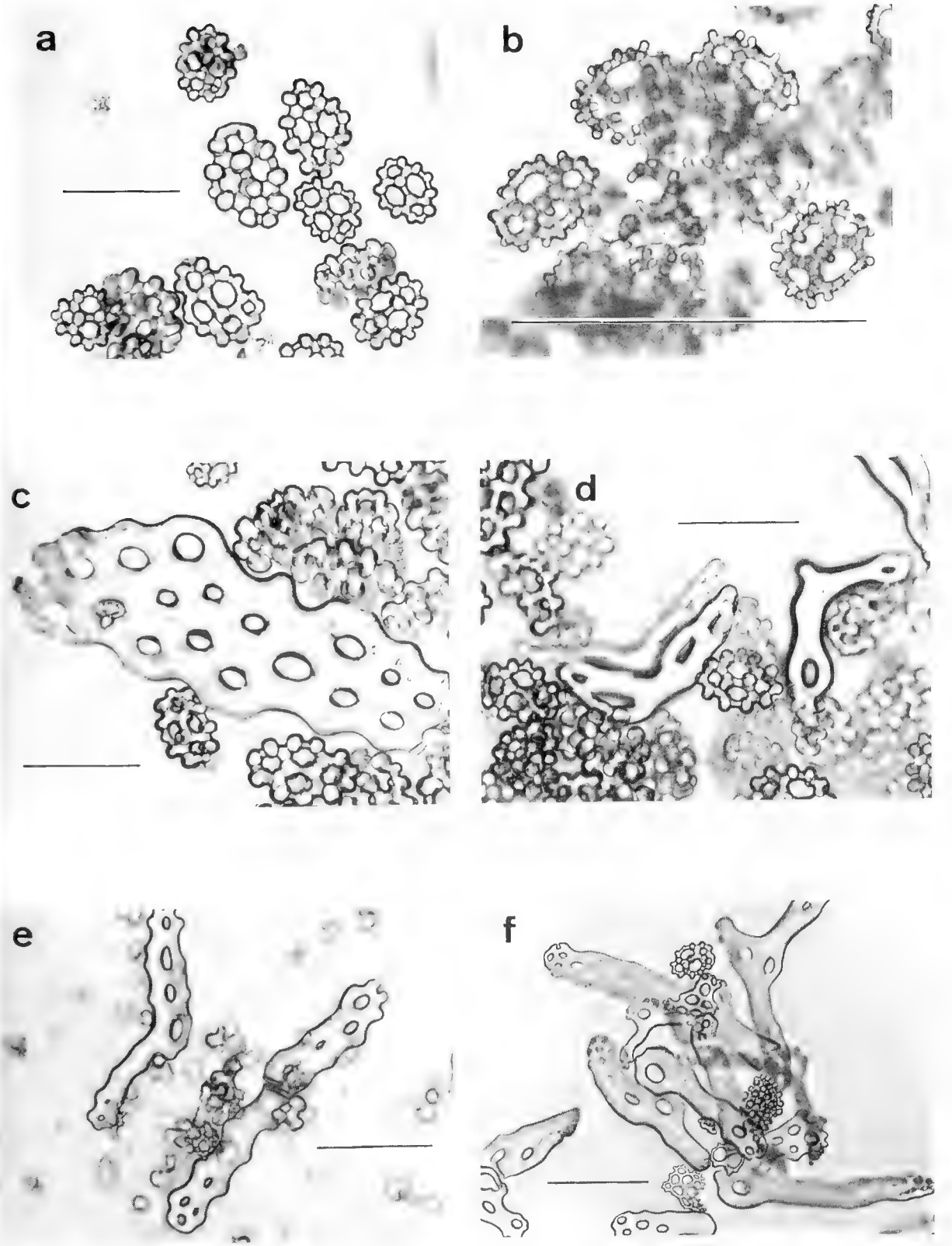


PLATE 9

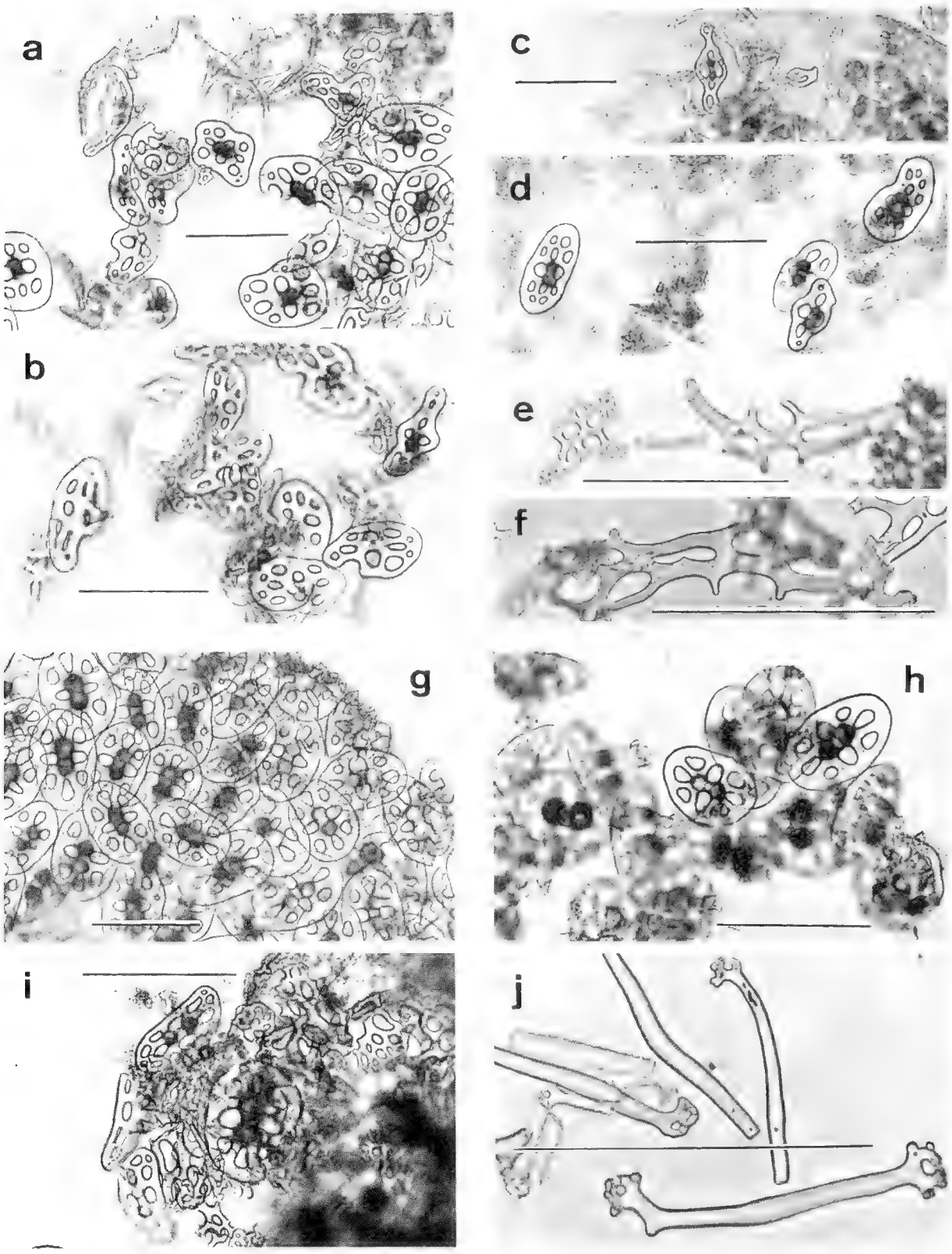


PLATE 10

Memoirs of the Museum of Victoria 53(2): 267–308 (1992)

FOUR NEW OCTOPUS SPECIES OF THE *OCTOPUS MACROPUS* GROUP (CEPHALOPODA: OCTOPODIDAE) FROM THE GREAT BARRIER REEF, AUSTRALIA

By Mark D. Norman

Invertebrate Zoology, Museum of Victoria, 285 Russell Street, Melbourne, Victoria 3000, Australia

Abstract

Norman, M.D., 1992. Four new octopus species of the *Octopus macropus* group (Cephalopoda: Octopodidae) from the Great Barrier Reef, Australia. *Memoirs of the Museum of Victoria* 53: 267–308.

Four new species of shallow-water octopuses are described from tropical waters of the Great Barrier Reef, Australia. All four are members of the "*Octopus macropus* group" (Robson, 1929), characterised by arms of unequal length with the dorsal pair longest (AF 1.2.3.4), moderate to high gill lamellae counts (10–14 per demibranch) and a robust conical copulatory organ. All are nocturnally active. Two species, *O. alpheus* and *O. aspilosomatis* spp. nov., occur in clear waters foraging predominantly on intertidal coral reefs and offshore islands. *O. dierythraeus* sp. nov. forages intertidally and subtidally on muddy substrates in coastal waters. *Octopus graptus* occurs in more open waters, on sandy and mud substrata in the channels and flat bottoms between islands. Full morphological descriptions are provided, along with details of known distributions, life history and commercial exploitation. Delineation of each species from related taxa is discussed.

Introduction

A number of workers have recognised the distinctive group of octopus species often referred to as the "*Octopus macropus* group" (Robson, 1929; Adam, 1941; Taki, 1944, 1964; Voss, 1981). Members of this species group are found in most tropical and temperate waters of the world and are characterised primarily by elongate arms with the dorsal pair longest (AF 1.2.3.4), moderate to high gill counts (10–14 per demibranch), a moderately large cylindrical copulatory organ with deep grooved ligula, and nocturnal activity patterns.

The species from which this group derives its name, *Octopus macropus* Risso, 1826, was described from the Mediterranean Sea. This species appears limited to the Mediterranean Sea and temperate eastern Atlantic (Hochberg, Mangold and Norman, in prep.). A number of species from Indo-West Pacific waters show close morphological and behavioural similarities with *O. macropus*. As a consequence, many of these species have regularly, and inappropriately, been assigned the name *O. macropus*, both within Australian waters [Girard, 1890; Brazier, 1892; Odhner, 1917; Nesis, 1982 (plate in 1987 abridged translation); Lu and Phillips, 1985], as well as elsewhere in the Indo-West Pacific region (Joubin, 1894, 1898; Goodrich, 1896; Hoyle, 1904; Berry, 1912, 1914; Wülker, 1913, 1920; Massy, 1916; Sasaki, 1920; Robson, 1926, 1929, 1932; Boone, 1938; Adam, 1939, 1942, 1946, 1954, 1959, 1960, 1973; Rees and Stuckey, 1954; Voss, 1963; Roper et al., 1984).

Sasaki (1920) was the first to question the supposed wide distribution of *O. macropus*, when tentatively assigning the name to a Japanese species: "(there is) much doubt whether the species extends as far as the Japanese waters from its home; that is, the Mediterranean Sea". Significant physical and temperature boundaries separate the distribution of the Indo-West Pacific species from that of *O. macropus* and there is no doubt that the Indo-West Pacific species are distinct taxa. A major review of the Indo-West Pacific members of the *O. macropus* group is required, including re-examination of species names from these waters previously synonymised under *O. macropus* (Robson, 1929; Roper et al., 1984).

Recent research into the shallow-water octopuses of the Great Barrier Reef and northern Australia has uncovered a surprisingly rich octopodan fauna (Norman, 1991, 1992a, 1992b, in prep.). At least 25 species have been recognised from these waters, of which only five can be assigned to previously described taxa. Amongst this rich fauna are five members of the *O. macropus* group. *Octopus ornatus* Gould, 1852 is a large species widely distributed throughout the tropical Indo-West Pacific. Norman (in prep.) describes the morphology of this species and its occurrence in Australian waters. The remaining four taxa are described here as new species: *O.*

alpheus, *O. aspilosomatis*, *O. dierythraeus* and *O. graptus* spp. nov.

A diagnostic key to the *O. macropus* group in Great Barrier Reef waters is provided along with full species accounts for the four new species. A diagnosis and distribution for *O. ornatus* is presented for comparison.

Material and methods

Field collection on the Great Barrier Reef was carried out between May and November in 1989 and 1990. Totals of 82 individuals of *O. alpheus*, 26 of *O. aspilosomatis* and 24 of *O. dierythraeus* were encountered live in the field, primarily at night on intertidal reef walks. Active lairs also were found intertidally on daylight reef walks, and subtidally through day and night snorkel and SCUBA dives. The occupants of these lairs were flushed using a weak solution of copper sulphate in sea water (<0.5 M) and captured in hand nets. Individuals were observed and photographed *in situ* and, where facilities were available, within aquaria.

Representative specimens were retained and narcotised in fresh water, and fixed and preserved according to the techniques of Roper and Sweeney (1983). These specimens are now housed in the Museum of Victoria (NMV). Additional specimens of all four new species were found in the collections of the Australian Museum, Sydney (AM), Queensland Museum, Brisbane (QM), National Museum of Natural History, Washington, (USNM) and Muséum National d'Histoire Naturelle, Paris (MNHN).

In the description and tables, measurements and indices follow Roper and Voss (1983). The terms "terminal organ" and "copulatory organ" are used to replace "penis" and "hectocotylus" respectively. These changes follow Hochberg and Mangold (in prep.). The structure historically known as the "penis" is not an intromittent organ and hence should not be referred to by this term. Terminal organ is a more appropriate term for this element of the male reproductive tract. The term "hectocotylus" refers to the entire modified arm and not the modified distal tip. This tip functions as the intromittent organ during copulation and is more appropriately named the copulatory organ.

The following additional or modified indices are also employed:

Stage of Maturity (StM): Immature (Imm: sex indeterminate or reproductive organs minute), Submature (S: reproductive organs distinct but poorly developed) and Mature (M: developed spermatophores or eggs distinct); Head Mantle Width Index (HMWI): head width as per cent of mantle width; Arm Mantle Index (AMI): arm length as per cent of ML; Arm Width Index (AWI): arm width at widest point on stoutest arm, as per cent of ML; Sucker Count (SC): total sucker count for intact arm with the highest sucker count; Gill Count (GC): number of gill lamellae per demibranch not including the medial terminal lamella; Hectocotylized Arm Mantle Index (HAMI): length of hectocotylized arm as per cent of ML; Hectocotylized Arm Sucker Count (HASC): number of suckers on hectocotylized arm; Terminal Organ Limb Index (TOLI): length of terminal organ as per cent of ML; Diverticulum Length Index (DLI): diverticulum length as per cent of length of terminal organ; Spermatophore number (SpN): number of spermatophores in Needham's Sac; Sperm Cord Whorls (SpCW): number of whorls in which sperm cord is coiled; Funnel Length Index (FLI): funnel length as per cent of ML; Free Funnel Index (FFI): length of free funnel portion as per cent of funnel length: Funnel Organ Index (FOI): length of outer limb of funnel organ as per cent of median limb length; Funnel Organ Length Index (FOLI): length of medial limb as per cent of funnel length.

In the descriptions, indices are presented for both sexes combined, except where significant differences were found between the sexes (one way ANOVA, $p = 0.05$). In these indices, range and mean for each sex are presented. Where ranges significantly overlap, standard deviations around the mean are also presented.

Table 1 summarises the key differences between Great Barrier Reef members of the *Octopus macropus* group.

Key to species of the "*Octopus macropus* group" from Great Barrier Reef waters

1. Distinctly elongate species with almost cylindrical arms and shallow webs, deepest web always less than 15% of length of longest arm, typically 10% 2
— Robust, moderately elongate species with deep webs, deepest web always greater than 15% of length of longest arm, typically 20% 3
2. Large species (to 130 mm ML, 1.2 m TL and 1 kg) with high gill counts

Table 1. Comparison of Great Barrier Reef species of the *Octopus macropus* group.

Species:	*O. alpheus*	*O. aspilosomatis*	*O. dierythraeus*	*O. graptus*	*O. ornatus*
Size: ML (mm)	80	80	135	190	130
TL (mm)	430	440	810	1300	1200
Weight (g)	340	120	1500	4200	1000
Arm length (AMI)	316.1–*421.0*–507.5	438.4–*537.6*–639.8	365.7–*477.5*–574.0	446.9–*537.9*–706.8	544.6–*688.1*–836.6
Web depth (WDI)	16.3–*21.8*–25.0	9.1–*11.6*–14.6	17.6–*20.3*–27.8	16.4–*20.0*–22.0	5.3–*8.7*–11.3
Sucker Count (SC)	192–*209*–228	206–*235*–267	234–*259*–280	194–*240*–280	324–*342*–382
Hectocotylised Arm SC	82–*91*–97	78–*85*–95	103–*112*–125	86–*87*–88	152–*164*–172
Gill Count	10–12	10–11	12–14	13–14	13–14
Funnel organ shape	typically W	W	UU	VV	W
Egg size	large	small	large	very large	small
Egg number	~100	~30 000	~350	~700	>30 000
Colour pattern	red, white spots	plain mantle	white, red spots	pale, scribbles	red, white bars

(13–14 lamellae per demibranch), high sucker counts (SC 324–*342*–382, HASC 152–*164*–172) and distinctive colour pattern of wide longitudinal white stripes on dorsal mantle and paired white spots on dorsal arm crown and arms, over brown to deep maroon base colour ..... *Octopus ornatus* Gould, 1852

— Medium sized species (to 80 mm ML, 440 mm TL and 120 g) with moderate gill counts (10–11 lamellae per demibranch) and moderate sucker counts (SC 206–*235*–267, HASC 78–*85*–95). Colour pattern of plain red or white dorsal mantle lacking spots, arm crown and dorsal arms covered with regular paired white spots over red base colour ..... *Octopus aspilosomatis* sp. nov.

3. Colour patterns consisting of red base colour with large white spots or the negative pattern of white base colour with red spots; W- or UU-shaped funnel organs 4

— Colour pattern simple, consisting of pale cream to pink base colour with dark brown "scribbling" (spots and short irregular lines) over dorsal mantle and arm crown (fig. 13a), VV-shaped funnel organ with outer limbs much shorter than medial limbs; very large robust species (to 190 mm ML, 1.3 m TL, 4.2 kg), gill counts high (13–14 per demibranch) ..... *Octopus graptus* sp. nov.

4. Large robust species (to 120 mm ML, 715 mm TL, 1.2 kg), with high gill counts (12–14 lamellae per demibranch) and moderate sucker counts (SC 234–*259*–280, HASC 103–*112*–125), funnel organ always UU-shaped, alarm display of large red spots over white base colour on dorsal mantle, arm crown and arms (figs 9a, 12c–d) ..... *Octopus dierythraeus* sp. nov.

— Medium sized species (to 80 mm ML, 430 mm TL, 340 g), with moderate gill counts (11–12 lamellae per demibranch) and moderate sucker counts (SC 192–*209*–228, HASC 82–*91*–97), funnel organ typically W-shaped, largest specimens with slight separation of medial limbs, alarm display of large white spots over red base colour on dorsal mantle, arm crown and arms (figs 1a, 4a–c) ..... *Octopus alpheus* sp. nov.

Octopodidae d'Orbigny, 1839

Subfamily **Octopodinae** d'Orbigny, 1839

Octopus ornatus Gould, 1852

Figure 17a

Diagnosis. Large muscular and elongate species with unequal arms, dorsal arms longest and most robust (AF 1.2.3.4), dorsal arms typically 6 to 7.5 times mantle length. Webs shallow, approximately 9% of length of longest arms. Sucker counts, 320–380 per arm in submature and mature animals, 150–170 suckers on hectocotylized arm of submature and mature males. Gill lamellae, 13–14 per demibranch, typically 14. Funnel organ W-shaped. Eggs small (to 3.5 mm long) produced in large numbers (>30 000). Alarm colouration of white longitudinal stripes on mantle and paired spots along aboral arm surfaces over maroon red base colour.

Distribution. Octopus ornatus is recorded from offshore islands of the southern Great Barrier Reef and several individuals from the warm-temperate waters of the New South Wales coast. This species is widely distributed throughout the tropical Indo-West Pacific region, from Hawaii to East Africa. Figure 17a presents the distribution of this species based on examined material and published records that clearly refer to this distinctive species.

Remarks. See Norman (in prep.) for full morphological description, annotated synonymy and details of life history based on Australian material. *Callistoctopus arakawai* Taki, 1964, described from southern Japan, is a junior synonym.

Octopus alpheus sp. nov.

Figs 1–4, 17b

Octopus macropus. — Nesis, 1982 (1987 abridged English translation): plate on p. 74. (non Risso, 1826)

Material examined. 82 individuals were encountered live in the field on the islands of the Capricorn Bunker Group at the southern end of the Great Barrier Reef.

18 were retained and are now in the Museum of Victoria. Six additional preserved specimens were found and examined in Australian museums and the National Museum of Natural History, Washington.

Holotype: Qld: 1♂: 74.2 mm ML, NMV F57930, Tryon I., Capricorn Bunker Group, 23°15′S, 151°47′E, 0.1–0.2 m, M. Norman, 2 Nov 1989 (active at 0435–0515 hr).

Paratypes: Qld: 1♂: 61.9; 1♀: 70.1 mm ML, NMV F60100, Tryon I., 23°15′S, 151°47′E, 0.1–0.2 m, M. Norman, 1 Nov 1989 (active at 0415–0530 hr); 1♀: 78.2 mm ML, NMV F65660, Tryon I., 23°15′S, 151°47′E, 0.1–0.2 m, M. Norman, 2 Nov 1989 (active at 0435–0515 hr).

Other material: Qld: 1♂: 19.7 mm ML, NMV F57928, One Tree I., 23°30′S, 152°05′E, 0.2 m, S. Jackson, 16 Oct 1989 (active at 1830 hr); 2♀: 20.2, 25.6 mm ML, NMV F57926, Tryon I., 23°15′S, 151°47′E, 0.1–0.2 m, M. Norman, 2 Nov 1989 (active at 0435–0500 hr, retreated into lair, flushed with $CuSO_4$); 1♀: 20.9 mm ML, AM C31668, Masthead I., 23°32′S, 151°45′E, D.B. Fry, no date; 1♀: 30.8 mm ML, AM C159263, North West I., 23°18′S, 151°42′E, M. Ward and W. Boardman, "Dec 1929–Jan 1931"; 1♀: 32.3 mm ML, QM Mo35762, Wilson I., 23°18′S, 151°55′E, 18 Sep 1972; 3♂, 4♀: 36.1–77.0 mm ML, NMV F65662, Tryon I., 23°15′S, 151°47′E, 0.1–0.2 m, M. Norman, 1 Nov 1989 (active at 0415–0530 hr); 1♂: 38.6 mm ML, NMV F57925, One Tree I., 23°30′S, 152°05′E, 0.2 m, R. Fenwick and M. Norman, 7 Sep 1990 (active at 1840 hr); 1♀: 40.2 mm ML, NMV F57929, Tryon I., 23°15′S, 151°47′E, 0.1 m, M. Norman, 31 Oct 1989 (active at 0520 hr); 1♂: 44.0 mm ML, NMV F57927, One Tree I., 23°30′S, 152°05′E, R. Fenwick and M. Norman, 7 Sep 1990 (active at 1910 hr); 1♂: 45.0 mm ML, AM C159262, Heron I., 23°26′S, 151°57′E, Dec 1964; 2♂, 1♀: 45.0–63.9 mm ML, NMV F60099, One Tree I., 23°30′S, 152°05′E, <0.3 m, M. Norman, 17 Oct 1989 (active at 1925–2100 hr); 1♂: 49.0 mm ML, USNM 817786, One Tree I., 23°30′S, 152°05′E, 0–2 ft (0–0.7 m), 22 Nov 1969 (rotenone station); 1♀: 65.8 mm ML, AM C159265, North West I., 23°18′S, 151°42′E, A.A. Livingstone and W. Boardman, "Dec 1930 to Jan 1931".

Diagnosis. Large muscular species with unequal arms, dorsal arms longest and most robust (AF 1.2.3.4), typically 3 to 4.5 times mantle length. Webs moderately deep, approximately 20% of length of longest arm. Sucker counts, 200–230 per arm in submature and mature animals, 80–100 suckers on hectocotylized arm of submature and mature males. Gill lamellae, 10–12 per demibranch, typically 11 on the outer demibranch and 12 on the inner demibranch. Funnel organ typically W-shaped. No mature females encountered, submature females with large-type eggs, produced in low numbers. Alarm colour pattern of large white spots over deep red base on dorsal surfaces of mantle, arm crown and arms.

Description. The following description is based on 2 submature and 3 mature males, and 7 submature females. Counts and indices for this material are presented in Tables 2 and 3, with data on 5 immature males and 3 immature females.

Moderate to large robust species (fig. 1a): no mature females found in this study, ML of submature females and mature males to at least 80 mm, TL to at least 430 mm; weight to at least 340 g. Mantle variable from round to elongate (MWI 39.7–*71.6*–89.2), mantle walls moderately muscular. Stylets present. Pallial aperture of moderate width, approximately half mantle width. Funnel long, muscular and broad based (FLI 48.0–*58.1*–69.2) with free portion approximately half funnel length (FFI 30.1–*46.7*–74.2). Funnel organ well developed (fig. 1b), typically W-shaped, except in 2 largest specimens (1♀: 78.2 mm ML and 1♂: 74.2 mm ML, NMV F57930 exhibited slight separation of the medial limbs approaching a UU-type funnel organ). Outer limbs of funnel organ slightly shorter than median limbs (FOI 75.0–*79.7*–83.6). Funnel organ approximately 50% of funnel length (FOLI 48.2–*53.3*–61.7).

Head of moderate width (HWI 43.0–*58.5*–74.6), typically narrower than mantle (HMWI 69.0–*82.5*–108.3). Neck distinct, slightly narrower than head. Eyes large and slightly pronounced.

Arms of moderate length, typically 3 to 5 times mantle length (AMI 316.1–*421.0*–507.5). Arms robust (AWI 14.7–*20.7*–25.9), roughly square in cross section and tapering evenly along length. Arms unequal in length, dorsal pair longest, ventral pair shortest (AF typically 1.2.3.4). Suckers of moderate to large size (SDI 11.9–*14.3*–17.4), deep with distinct radial cushions and scalloped outer rim. Scalloping exaggerated on small distal suckers to form ring of small digits of skin around rim of sucker. Suckers largest on dorsal arms, none especially enlarged in either sex. Approximately 200 suckers per intact normal arm, with slightly higher counts in females (SC♂ 192–203 ± 9.98–216, n = 4♂; ♀ 208–217 ± 8.32–228, n = 5♀). Webs of moderate depth (WDI 16.3–*21.8*–25.0), deepest dorsally evenly decreasing in depth to shortest ventral web (WF typically A.B.C.D.E). Web margins extended on ventral edges of arms for majority of length.

Right third arm in males hectocotylized, slightly shorter than opposite arm (OAI: 68.5–*70.3*–72.1; HAMI: 197.8–*225.9*–274.6). Copulatory organ (fig. 1c) of moderate size [LLI(mat)

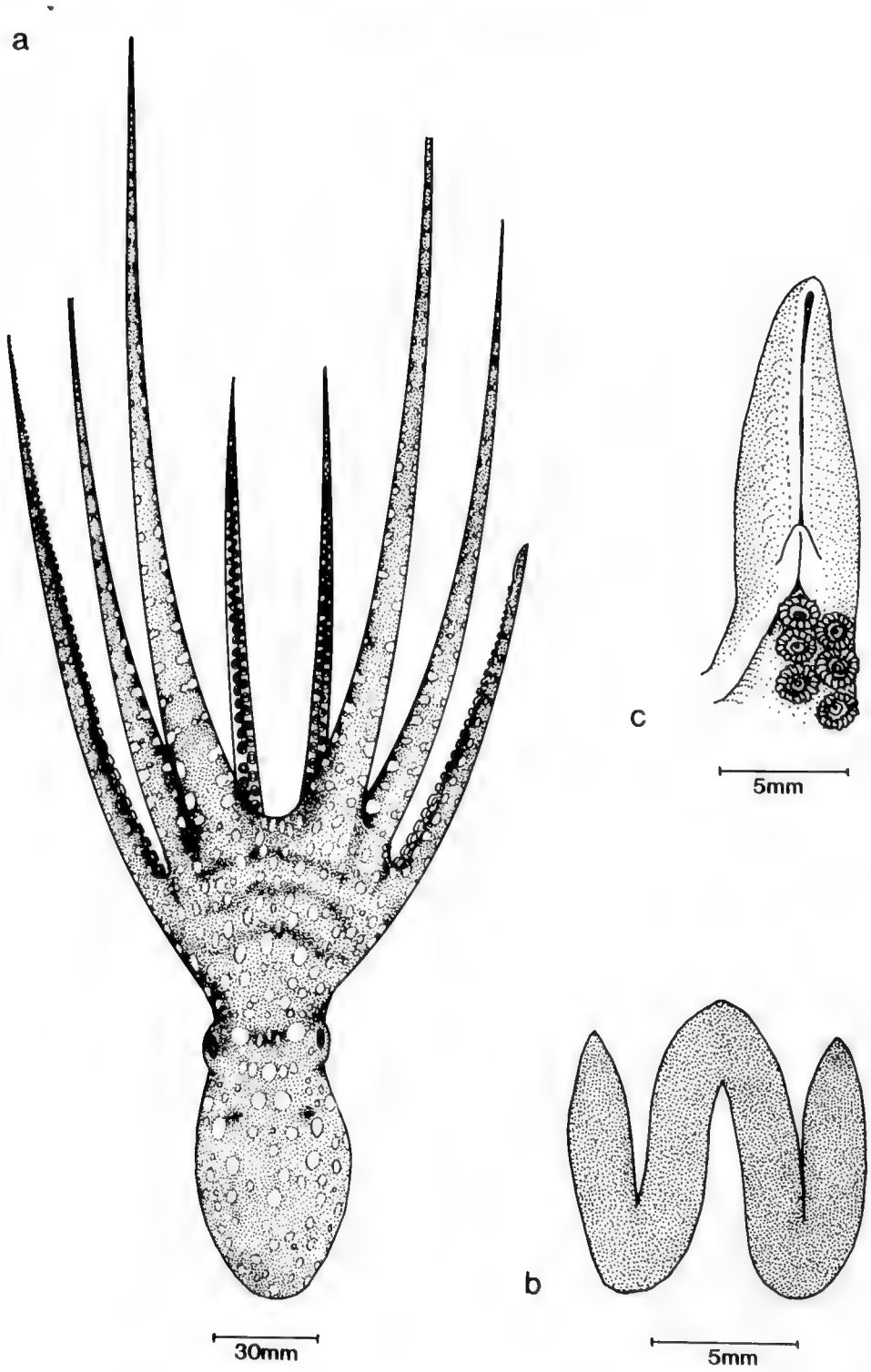


Figure 1. *Octopus alpheus* sp. nov. a, dorsal view of 74.2 mm ML male (holotype, NMV F57930). b, funnel organ of 41.0 mm ML male (NMV F65662). c, copulatory organ of 74.2 mm ML male (holotype, NMV F57930).

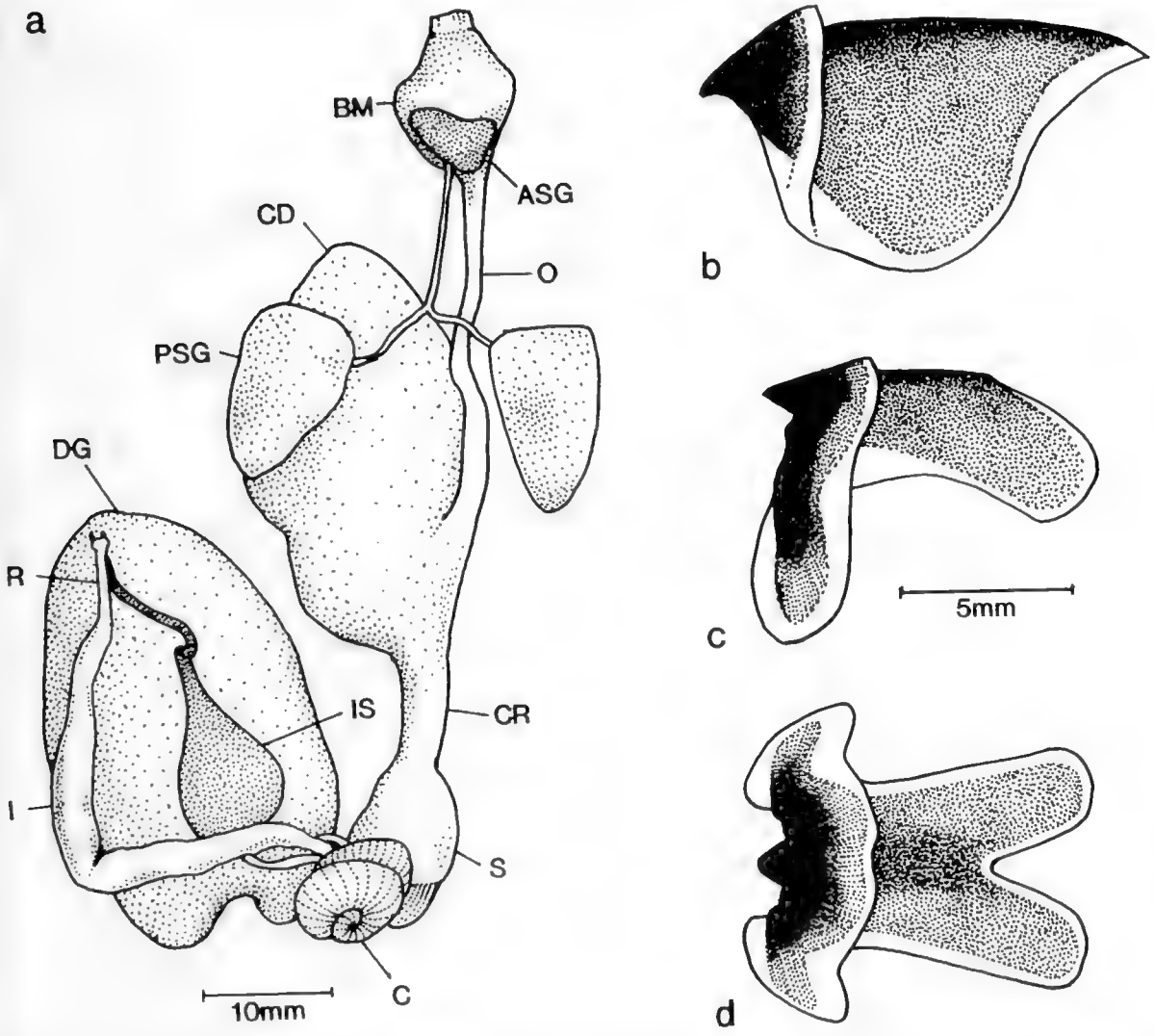


Figure 2. *Octopus alpheus* sp. nov. a, digestive tract of 43.3 mm ML male (NMV F65662). ASG = anterior salivary glands; BM = buccal mass; C = caecum; CD = crop diverticulum; CR = crop; DG = digestive gland; I = intestine; IS = ink sac; O = oesophagus; PSG = posterior salivary gland; R = rectum; S = stomach. b–d, beaks of 77.0 mm ML female (NMV F65662). b, upper beak, lateral view. c, lower beak, lateral view. d, lower beak, ventral view.

5.3–*7.2*–9.1], roughly cylindrical with deep ligula groove and moderate calamus [CLI(mat) 20.9–*23.9*–28.9]. Ligula groove contains >20 fine transverse grooves. Spermatophore groove well developed and wide with fine transverse grooves. Spermatophore guide distinct with moderately deep notch and flattened ridge topped with square papillae. Approximately 90 suckers on hectocotylized arm (HASC 82–*91*–97).

Gills with 10–12 lamellae on each demibranch, typically 11 on outer and 12 on inner demibranch. Terminal lamella small.

Digestive tract illustrated in figure 2a. Anterior salivary glands approximately one-third of buccal mass length. Posterior salivary glands slightly longer than buccal mass. Crop diverticulum large in the 2 specimens dissected, almost as large as digestive gland but possibly distended by contents. Stomach bipartite. Caecum clearly striated, coiled in 1.5 to 2 whorls. Intestine thin walled and reflexed in proximal third. Rectum straight and muscular. Ink sac well developed, embedded in ventral surface of digestive gland. Ink red when released by live animals. Fleshy anal flaps present.

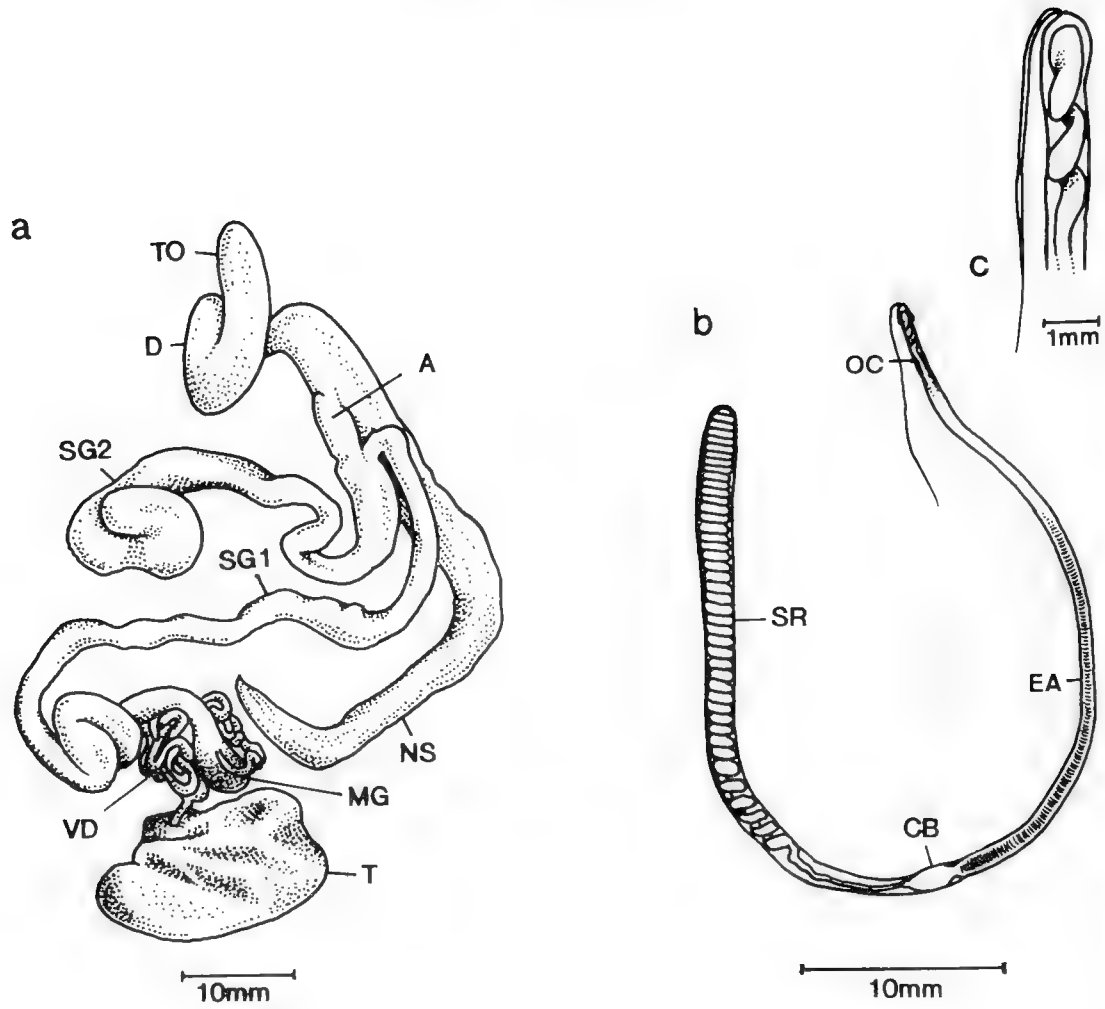


Figure 3. *Octopus alpheus* sp. nov. a, reproductive tract of 74.2 mm ML male (holotype, NMV F57930). A = appendix; D = diverticulum; MG = mucilaginous gland; NS = Needham's Sac; SG1 = spermatophoric gland I; SG2 = spermatophoric gland II; T = testes; TO = terminal organ; VD = vas deferens. b–c, spermatophore of same specimen. b, whole spermatophore. CB = cement body; EA = ejaculatory apparatus; OC = oral cap; SR = sperm reservoir. c, detail of oral cap.

Upper beak (fig. 2b) with small hood and weakly hooked rostrum. Lower beak (figs 2c–d) with moderately sharp rostrum, narrow hood, widely spread wings and flared lateral walls. Ventral view of posterior margin of lateral walls deeply concave. Radula with 7 transverse rows of teeth and marginal plates (figs 4e–f). Rhachidian tooth has 2–3 lateral cusps, typically 3, on each side of large curved medial cusp. Lateral cusps in asymmetrical seriation, migrating from lateral to medial position over 8–9 rows. First lateral teeth small and unicuspidate; second lateral teeth unicuspidate, of moderate length and robust; lateral marginal teeth relatively straight, short and robust; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 3a. Terminal organ in mature males of moderate length and very robust (TOLI 19.2, 24.8, 32.4) with robust diverticulum (DLI 53.8, 57.5, 58.1). Genital aperture subterminal. Mucilaginous gland enlarged at point of attachment to vas deferens. Spermatophoric gland I narrow with large recurved coil approximately 80% along length. Spermatophoric gland II robust and moderately short with reflexed tip. Spermatophores (figs 3b–c) almost as long as mantle length (SpLI 92.3, 93.7, 95.1), of moderate width (SpWI 2.6, 2.9,

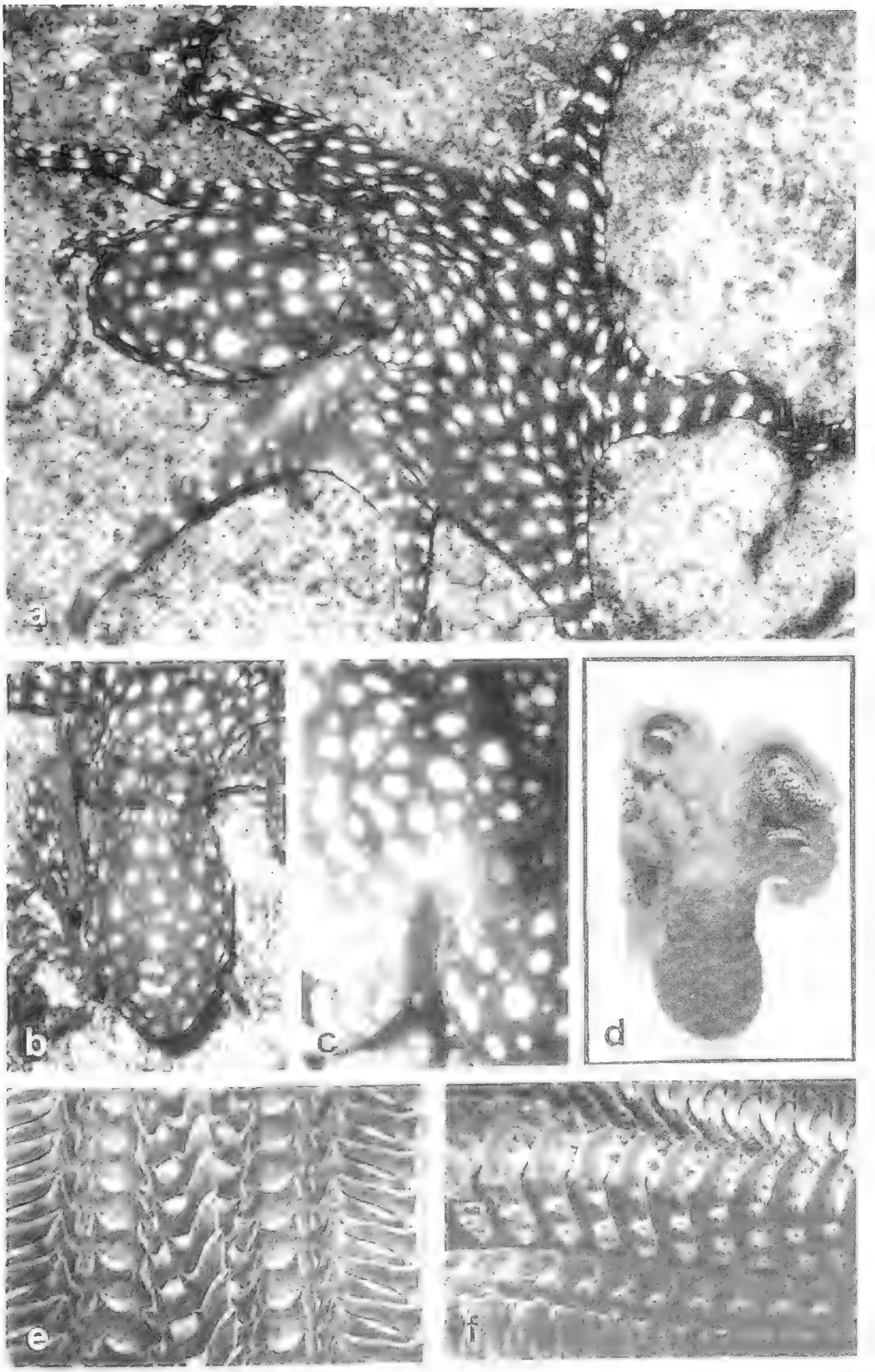


Figure 4. *Octopus alpheus* sp. nov. a–c, active individuals on reef flats at night on Tryon I. d, dorsal view of preserved 74.2 mm ML male (holotype, NMV F57930), showing wavy transverse lines on dorsal arm crown. e–f, radula of 77.0 mm ML female (NMV F65662). e, dorsal view. f, lateral view.

Table 2. Counts and indices for male *Octopus alpheus* sp. nov.
(D = damaged; Imm = immature; InD = indistinct; M = mature; S = submature).

Museum Reg. No.	NMV F57928	NMV F57925	NMV F65662	NMV F57927	AM C159262	NMV F60099	NMV F65662	NMV F60100 (Paratype)	NMV F60099	NMV F57930 (Holotype)
ML	19.7	38.6	41.0	44.0	45.0	45.0	45.6	61.9	63.9	74.2
StM	Imm	Imm	Imm	Imm	S	S	Imm	M	M	M
TL	83	198	222	217	227	257	211	372	>338	361
MWI	74.1	74.6	57.3	73.2	71.3	82.4	55.5	79.0	84.5	60.4
HWI	60.9	56.7	49.5	57.7	55.1	66.4	46.5	74.6	67.9	51.6
HMWI	82.2	76.0	86.4	78.8	77.3	80.6	83.8	94.4	80.4	85.4
AMI: 1	304.6	399.0	419.5	372.7	373.3	448.9	339.9	487.9	D	361.2
2	294.4	352.3	361.0	343.2	322.2	371.1	333.3	415.2	394.4	308.6
3	258.9	285.0	319.5	D	288.9	D	296.1	D	D	274.9
H	213.2	207.3	209.8	218.2	197.8	224.4	208.3	274.6	234.7	198.1
4	243.7	287.6	307.3	261.4	262.2	328.9	285.1	378.0	317.7	D
AWI	18.3	18.7	15.6	19.5	19.8	22.0	14.3	14.7	25.8	21.6
SDI	12.2	13.7	12.7	16.4	12.9	15.8	11.8	14.1	17.4	14.4
WDI	24.2	19.5	20.3	19.0	24.4	16.3	20.0	21.9	23.8	18.7
GC	11/12	11	11/10	11	11/12	11/12	12	11/12	11/12	12/12
SC						200	193	216	203	192
HAMI	213.2	207.3	209.8	218.2	197.8	224.4	208.3	274.6	234.7	198.1
OAI	82.4	72.7	65.6	D	68.5	D	70.4	D	D	72.1
HASC	97	92	88	101	84	96	87	98	97	82
LLI	InD	3.0	2.9	4.3	3.9	3.3	3.2	5.3	7.3	9.1
CLI	InD	25.0	40.0	36.6	34.3	30.3	40.0	28.9	22.0	20.9
TOLI	6.6	5.7	4.4	InD	InD	InD	5.3	19.2	32.4	24.8
DLI	InD	59.1	InD	InD	InD	InD	InD	57.5	53.8	58.1
SpLI								93.7	95.1	92.3
SpWI								2.6	3.1	2.9
SpRI								55.3	47.7	45.1
SpN									2	3
FLI	54.8	55.4	59.5	48.0	59.1	54.0	61.0	55.7	59.8	52.8
FFI	39.8	57.0	41.8	72.5	30.1	46.5	50.0	52.8	74.2	31.4
FOI	83.1	71.7	81.3	InD	76.3	75.0	77.4	82.2	79.6	82.2
FOLI	54.6	56.1	45.9	InD	57.1	57.6	44.6	61.7	53.9	50.3

Table 3. Counts and indices for female *Octopus alpheus* sp. nov.
(D = damaged; Imm = immature; InD = indistinct; S = submature; * = measurements from immature ovarian eggs).

Museum Reg. No.	NMV F57926	NMV F57926	NMV F65662	AM C57929	NMV F65662	NMV F60099	AM C159265	NMV F60100 (Paratype)	NMV F65662	NMV F65660 (Paratype)
ML	20.2	25.6	36.1	40.2	47.7	57.5	65.8	70.1	77.0	78.2
StM	Imm	Imm	Imm	S	S	S	S	S	S	S
TL	82	110	173	260	293	320	288	378	399	434.0
MWI	60.9	65.2	54.6	79.6	79.0	89.2	39.7	68.8	60.4	65.1
HWI	61.9	57.8	43.2	67.2	62.9	69.4	43.0	49.6	41.7	52.3
HMWI	101.6	88.7	79.1	84.4	79.6	77.8	108.3	72.1	69.0	80.3
AMI: 1	D	304.7	360.1	507.5	473.8	427.8	316.1	406.6	392.2	436.1
2	267.3	277.3	326.9	460.2	381.6	391.3	278.1	375.2	363.6	D
3	257.4	250.0	296.4	410.4	377.4	368.7	250.8	333.8	322.1	347.8
4	242.6	238.3	243.8	415.4	327.0	365.2	244.7	332.4	280.5	317.1
AWI	17.3	18.0	12.5	23.1	18.2	25.9	18.4	19.5	17.4	22.4
SDI	12.4	11.7	10.0	11.9	15.1	17.4	12.3	13.0	11.9	15.1
WDI	24.8	21.9	20.0	20.1	22.6	23.6	25.0	22.5	19.9	23.2
GC	11	11/12	11/12	11/12	11/12	11/12	11/11	11/12	12	11
SC						222	208	228	210	218
ELI								5.7*		6.9*
EWI									1.3*	
EN				~100		<100	<100	<100	<100	<100
FLI	54.5	48.8	48.5	D	69.2	61.0	53.0	55.9	61.7	56.8
FFI	48.1	39.1	43.5	D	53.9	49.3	35.8	44.2	60.6	34.7
FOI	70.7	83.6	InD	InD	79.8	79.6	79.1	79.5	InD	83.6
FOLI	52.7	53.6	InD	InD	52.4	51.1	49.3	51.0	InD	48.2

3.1) and produced in low numbers (2 and 3 in Needham Sacs of 2 specimens). Oral cap simple bearing long cap thread. Sperm reservoir approximately half of spermatophore length (SpRI 45.1, 47.7, 55.3), sperm cord coiled in approximately 40 regular whorls.

No mature females were encountered in this study. Immature ovaries were visible in submature females, poorly developed in even the largest female. Large type eggs in low numbers clearly visible in undeveloped ovaries. Very small ovary of 1 female (78.2 mm ML: NMV F57930) contained approximately 130 long thin immature eggs up to 5.4 mm long. Approximately 22 follicular folds visible on immature eggs. Mature eggs would be very large and produced in low numbers.

Colour in life orange (to deep red in alarm display) covered in circular white spots over dorsal body, arm crown, webs and arms (figs 1a, 4a–c). Spots on arms paired and evenly spaced. Additional spots on dorsolateral faces of arms including 1 on the base of each sucker on at least arms 1 and 2. Pairs of slightly darker markings on dorsal mantle. Iridescent tissue layer present in skin, giving iridescent green sheen in torchlight at night.

Skin sculpture simple, consisting of scattered low papillae located in the centre of white spots, especially on dorsal and lateral mantle. Transverse pair of large papilla in largest white spots on dorsal mantle. Small punctae scattered between papillae on dorsal surfaces. Single slightly larger supraocular papilla directly above each eye, surrounded by low papillae. Pigmentation and sculpture do not extend to oral surface of webs.

Preserved specimens tend to lose dark red colour and definition of spots, base colour fading to cream. Pale spots containing central papilla sometimes visible on mantle, especially on lateral faces. Two to three dark wavy transverse lines across dorsal arm crown often visible.

There appears to be little sexual dimorphism in this species. Sucker counts were slightly lower for males in material examined.

Distribution. Offshore islands of the Capricorn Bunker group at the southern end of the Great Barrier Reef, Queensland (fig. 17b). Specimens have been collected from Tryon (23°15′S, 151°47′E), Northwest (23°18′S, 151°42′E), Wilson (23°18′S, 151°55′E), Heron (23°26′S, 151°57′E), One Tree (23°30′S, 152°05′E) and Masthead Islands (23°32′S, 151°45′E).

Life history. Nocturnally-active species which forages on exposed intertidal coral reef flats on offshore islands. Preys on small crabs and other crustaceans by probing crevices and burrows with arm tips. This species occupies lairs within coral bedrock and under living coral, closing entrance during the day with pieces of dead coral. It is unclear whether lairs are permanent or temporary refuges. Animals only emerge after dark.

A total of 82 individuals was encountered actively foraging, always in less than 0.3 m on exposed reef flats. Individuals were only encountered at night between 1840 and 0600 hr. No specimens were encountered subtidally, either during the day or at night.

This species often emerges from pools and traverses areas of exposed reef whilst foraging. Water was not retained within the mantle cavity while animals traversed exposed sections of reef. Individuals were often heard making whistling or squeaking noises when in very shallow pools or traversing dry ground as they drew air in and out of the mantle cavity.

This species also tolerates low salinities, being difficult to narcotise in freshwater. This tolerance may relate to the intertidal habits of this species where rain can cause locally low salinities in closed and shallow pools.

Foraging individuals often were captured carrying small crabs on suckers close to the mouth. Several were caught carrying much larger crabs (up to 100 mm carapace width). Examination of stomach contents revealed only crustacean remains.

Foraging individuals of *O. alpheus* appeared tolerant of conspecifics, often crawling over each other whilst seeking prey without any observed aggression. This tolerance was not observed by congeneric octopuses which appear to be a predator of at least smaller members of this species. One small individual of *O. alpheus* was attacked and partially devoured by a large individual of *O. ornatus* Gould, 1852 when released into an aquarium containing the latter species. The stomach contents of *O. ornatus* has been found to contain the beaks of smaller octopuses (Norman, in prep.).

Large eggs indicate young adopt a benthic habit on hatching.

Etymology. From the Latin "*alphus*" meaning white spots on the skin, referring to the white spots generated in the alarm display of this species (fig. 4a).

Remarks. The colour plates in the 1987 abridged English translation of Nesis (1982) show an indi-

vidual of *O. alpheus* at Heron I., under the heading *O. macropus*. The distinctive colour pattern and locality of this specimen clearly identify it as an individual of *O. alpheus*.

Octopus aspilosomatis sp. nov.

Figs 5–8, 17c

Octopus ornatus. — Roper and Hochberg, 1987: 16, 18. — 1988: 161. (non Gould, 1852).

Material examined. 25 individuals were encountered live in the field on Lizard and Russell islands and on the mainland coast at Cape Tribulation. 21 were retained and are now in the Museum of Victoria. 4 additional preserved specimens were found and examined in the collections of the Australian Museum and the National Museum of Natural History, Washington.

Holotype: Qld: 1♂: 42.1 mm ML, NMV F67001, Russell I., Frankland Group, 17°14′S, 146°06′E, <0.1 m, M. Norman and S. Troy, 19 Oct 1990 (active at 0255 hr).

Paratypes: Qld: 1♂: 42.2 mm ML, NMV F60148, Casuarina Beach, Lizard I., 14°41′S, 145°27′E, 0.1 m, M. Norman, 14 Nov 1989 (active at 0440–0530 hr); 1♂: 44.7 mm ML, NMV F60149, Coconut Beach, Lizard I., Tryon I., 14°40′S, 145°28′E, <0.1 m, M. Norman, C. Davies and J. Martin, 15 Nov 1989 (active at 0450 hr); 1♀: 56.8 mm ML, NMV F60147, Russell I., Frankland Group, 17°14′S, 146°06′E, <0.1 m, M. Norman, S. Troy, 19 Oct 1990 (active at 0335–0350 hr); 1♀: 67.1 mm ML, NMV F60145, Casuarina Beach, Lizard I., 14°41′S, 145°27′E, 0.1 m, M. Norman, 13 Nov 1989 (active at 0330–0515 hr).

Other material: Qld: 4♂: 25.4–34.4, 1♀: 36.4 mm ML, NMV F67002, Coconut Beach, Cape Tribulation National Park, 16°05′S, 145°29′E, <0.2 m, M. Norman, S. Troy, 16 Oct 1990 (active at 0020–0145 hr); 1♀: 27.5 mm ML, USNM 817667, off Coconut Beach, Lizard I., 14°40′S, 145°28′E, 3 m, in open water 25–30 m deep, Larval Fish Survey, 27 Dec 1986 (in floating night light trap); 3♂: 30.5–51.8, 1♀: 50.7 mm ML, NMV F60144, Coconut Beach, Lizard I., 14°40′S, 145°28′E, <0.1 m, M. Norman, C. Davies and J. Martin, 15 Nov 1989 (active at 0450 hr); 1♂: 37.3 mm ML, NMV F65659, Casuarina Beach, Lizard I., 14°41′S, 145°27′E, 0.1 m, M. Norman, 14 Nov 1989 (active at 0440–0530 hr); 3♀: 39.0–45.9 mm ML, NMV F65664, Casuarina Beach, Lizard I., 14°41′S, 145°27′E, 0.1 m, M. Norman, 13 Nov 1989 (active at 0330–0515 hr); 1♂: 39.3, 1♀: 39.8 mm ML, NMV F65661, Russell I., Frankland Group, 17°14′S, 146°06′E, <0.1 m, M. Norman, S. Troy, 19 Oct 1990 (active at 0335–0350 hr); 2♂: 49.3, 83.2 mm ML, AM C159275, Casuarina Beach, Lizard I., 14°41′S, 145°27′E, W.F. Ponder, P.H. Colman, I. Loch, 29 Nov 1974 (active at night); 1♂: 67.9 mm ML, NMV F60146, Casuarina Beach, Lizard I., 14°40′S, 145°28′E, 0.2 m, M. Norman, 13 Nov 1989 (active at 0325 hr).

Diagnosis. Moderate sized, elongate species with unequal arms, dorsal pairs longest (AF 1.2.3.4), typically 4.5–6 times mantle length. Webs shallow, approximately 10% of length of longest arm. Sucker counts, 200–260 per arm in submature and mature animals, 78–95 suckers on hectocotylized arm of submature and mature males. Gill lamellae, 10–11 per demibranch, typically 10 on outer demibranch and 11 on inner demibranch. Funnel organ W-shaped. No mature females encountered, submature females with small-type eggs, produced in large numbers (about 30 000 in 1 specimen). Alarm colour pattern of red dorsal mantle and arms, and paired white spots on arm crown and aboral surface of arms only.

Description. The following description is based on 4 submature and 6 mature males, and 10 submature females. Counts and indices for this material are presented in Tables 4 and 5.

A number of specimens of *O. aspilosomatis* possess greatly elongated mantles where the mantle becomes almost cylindrical (fig. 8d). Voss (1981) reported such variation in mantle shape in *O. ornatus*, variation also witnessed in Australian material of *O. ornatus* (Norman, in prep.). Certain indices are presented separately for normal and elongate material in the description below.

Moderate sized, elongate species (fig. 5a): no mature females found in this study, ML of submature females and mature males to at least 80 mm, TL to at least 440 mm; weight to at least 120 g. As in *Octopus ornatus*, mantle is highly variable from ovoid to extremely elongate in some preserved specimens (fig. 8d: MWI 27.5–*52.5*–72.9), mantle walls moderately muscular. Stylets present. Pallial aperture of moderate width, slightly greater than half mantle width. Funnel long, muscular and broad based (FLI 30.9–*48.1*–61.1) with free portion variable in length, typically around half funnel length (FFI 28.6–*51.2*–86.8). Funnel organ well developed (fig. 5b), W-shaped with broad limbs. Outer limbs clearly shorter than median limbs (FOI 58.4–*66.9*–84.0). Funnel organ approximately 50% of funnel length (FOLI 44.6–*52.5*–61.7).

Head of moderate width (HWI 26.8–*46.3*–55.3), generally narrower than mantle (HMWI 73.4–*90*–109.8). Neck distinct, slightly narrower than head. Eyes large and pronounced, especially in elongate form.

Arms long, typically 4.5 to 6 times mantle length (AMI 438.4–*537.6*–639.8, n = 13, 314.9–*391.4*–411.2 in elongate forms, n = 4). Arms robust (AWI 9.9–*14*–19.9), square in cross section and tapering evenly along length. Arms

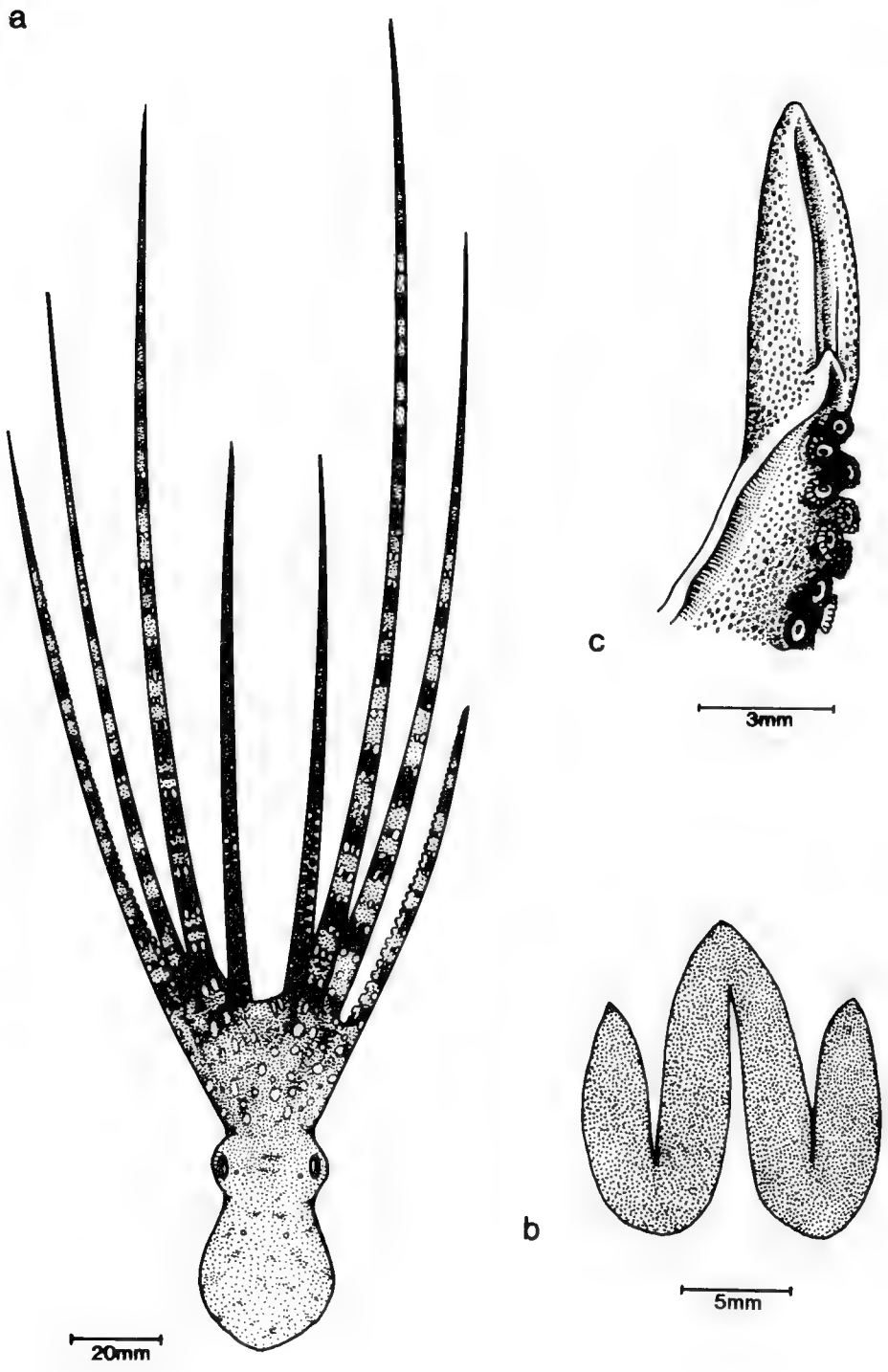


Figure 5. *Octopus aspilosomatis* sp. nov. a, dorsal view of 42.1 mm ML male (holotype, NMV F67001). b, funnel organ of same specimen. c, copulatory organ of same specimen.

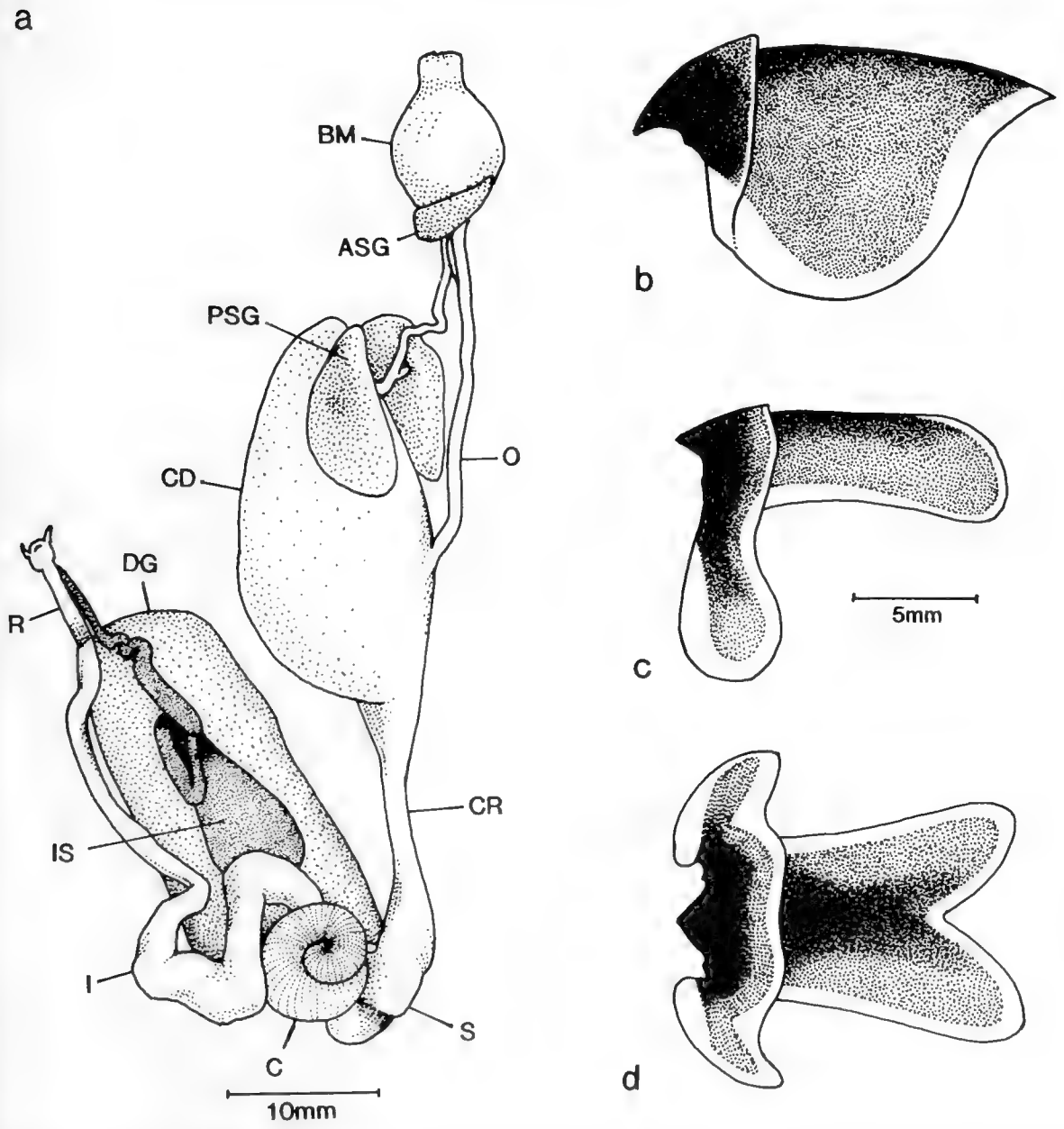


Figure 6. *Octopus aspilosomatis* sp. nov. a, digestive tract of 50.7 mm ML female (NMV F60144) [abbreviations as in fig. 2a]. b–d, beaks of 46.7 mm ML male (paratype, NMV F60149). b, upper beak, lateral view. c, lower beak, lateral view. d, lower beak, ventral view.

unequal in length, dorsal pair longest, ventral pair shortest (AF typically 1.2.3.4). Suckers biserial, of moderate size and slightly larger in males [SDI♂ (normal) 11.4–*12.4*–13.2, SDI♂ (elongate forms) 6.4–*8.2*–9.8; SDI♀ 6.7–*8.5*–9.6]. Suckers deep with fine radial cushions and scalloped outer rim. Suckers largest on dorsal arms, none especially enlarged in either sex. Approximately 230 suckers per intact normal arm in both sexes (SC 206–*235*–267). Webs shallow (WDI 9.1–*11.6*–14.6), shortest ventrally, remaining webs subequal (WF typically A=B=C=D.E). Web margins extended on ventral edges of arms for majority of length.

Right third arm in males hectocotylized, slightly shorter than opposite arm (OAI: 55.0–*60.5*–65.9; HAMI: 134.6–*210.4*–279.6). Copulatory organ (fig. 5c) of moderate size [LLI(mat)

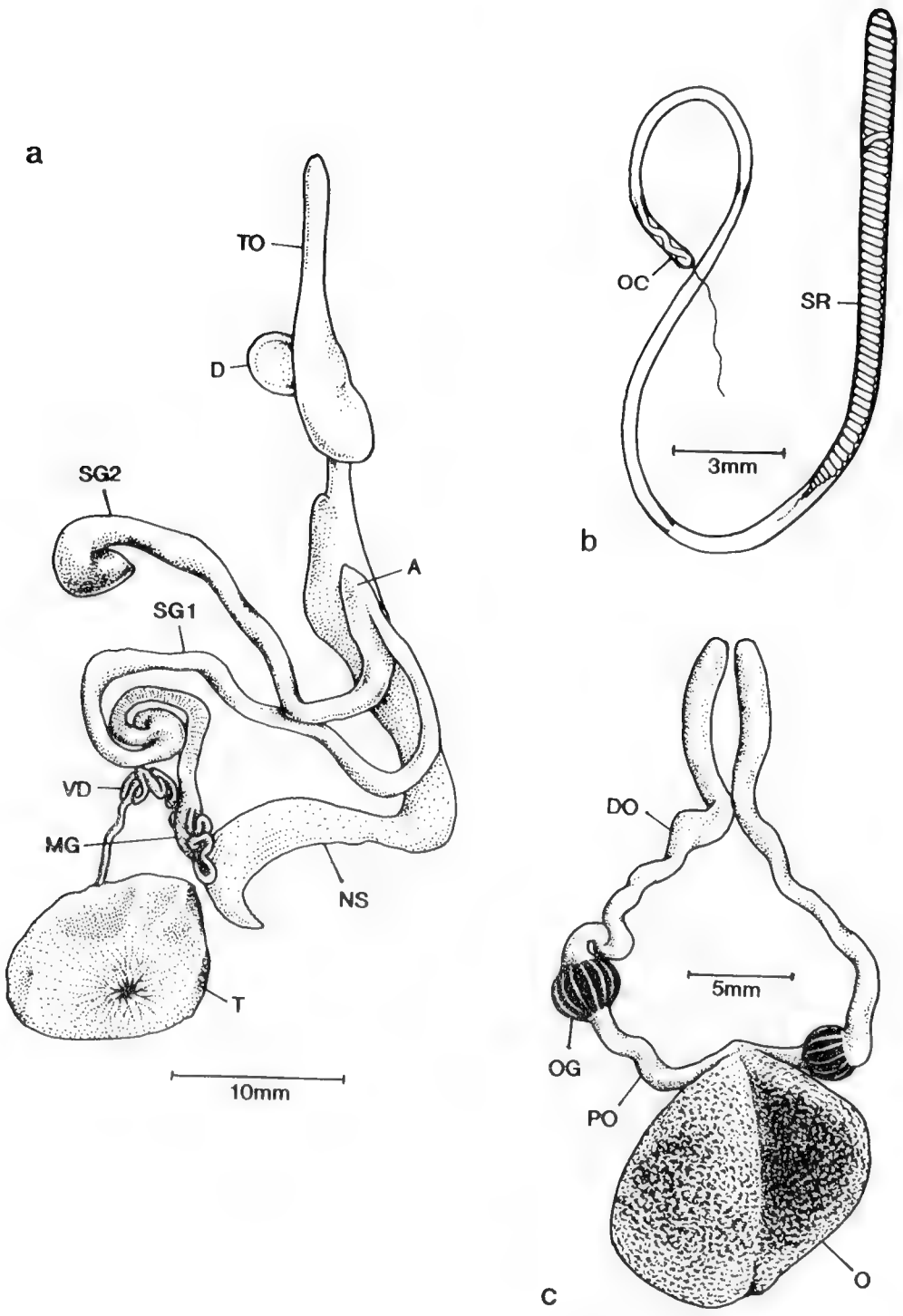


Figure 7. *Octopus aspilosomatis* sp. nov. a, reproductive tract of 67.9 mm ML male (NMV F60146) [abbreviations as in fig. 3a]. b, spermatophore of 83.2 mm ML male (AM C159275). OC = oral cap; SR = sperm reservoir. c, immature ovary of 67.1 mm ML female (paratype, NMV F60145). DO = distal oviduct; O = ovary; OG = oviducal gland; PO = proximal oviduct.

6.1–*7.5*–8.8, n = 6], roughly cylindrical with deep ligular groove and moderate calamus [CLI(mat) 15.5–*21.1*–29.3]. Ligula groove deep and typically closed. Spermatophore groove well developed and wide with fine transverse grooves. Spermatophore guide distinct with moderately deep notch and flattened ridge topped with square papillae. Approximately 85 suckers on hectocotylized arm (HASC 78–*85*–95).

Gills with 10–11 lamellae on each demibranch, typically 10 on outer and 11 on inner demibranch. Terminal lamella small.

Digestive tract illustrated in figure 6a. Anterior salivary glands approximately one-third of buccal mass length. Posterior salivary glands approximately equal in length with buccal mass. Crop diverticulum large in the specimen dissected, larger than digestive gland but distended by contents. Stomach bipartite. Caecum clearly striated, coiled in 1.5–2 whorls. Intestine thin walled, reflexed in proximal third. Rectum muscular and straight. Ink sac well developed and elongate, ink duct long. Ink red when released by live animals. Fine elongate anal flaps present. Membrane on dorsal surface of visceral mass pigmented with large dark chromatophores, presumably remnants of larval or founder chromatophores.

Upper beak (fig. 6b) with small hood and weakly hooked rostrum. Lower beak (figs 6c–d) with moderately sharp rostrum, narrow hood, widely spread wings and flared lateral walls. Ventral view of posterior margin of lateral walls deeply concave. Radula with 7 transverse rows of teeth and marginal plates (figs 8g–h). Rhachidian tooth has 2–3 lateral cusps on each side of large curved medial cusp. Lateral cusps in asymmetrical seriation, migrating from lateral to medial position over 8–9 rows. First lateral teeth small and unicuspidate; second lateral teeth unicuspidate, of moderate length and robust; lateral marginal teeth curved and relatively fine; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 7a. Terminal organ in mature males of moderate length and robust [TOLI(mat) 21.4–*26.2*–33.6] with robust diverticulum (DLI 48.5–*55.4*–61.3). Genital aperture subterminal. Mucilaginous gland enlarged at point of attachment to short and robust vas deferens. Spermatophoric gland I narrow with large recurved coil approximately 80% along length. Spermatophoric gland II narrow and moderately long with reflexed tip. Spermatophores (fig. 7b) approximately 80% of mantle length, proportionally shorter in elongate forms [SpLI (normal) 75.1, 82.9, SpLI (elongate) 47.8], of moderate width (SpWI 2.5–2.6) and produced in low numbers (1–3 in Needham Sacs of 3 specimens). Oral cap simple bearing long cap thread. Sperm reservoir approximately half of spermatophore length (SpRI 46.2, 54.3), sperm cord coiled in approximately 55 regular whorls.

No mature females encountered. Immature ovaries were visible in submature females. Small type eggs in high numbers were clearly visible in undeveloped ovaries. Largest female (67.1 mm ML paratype, NMV F60145) possessed an immature ovary 14 mm in diameter with elongate narrow oviducts and oviducal glands containing approximately 15 braiding chambers (fig. 7c). This ovary contained about 30 000 immature eggs up to 1.1 mm long. 6 follicular folds were visible in these undeveloped eggs. Mature eggs would be small and produced in large numbers.

Colour in life orange to deep red on the mantle, arm crown and aboral surfaces of all arms. White spots on arm crown and arms in most colour patterns (figs 8a, c–f). Spots on arms paired and evenly spaced. Transverse pair of small dorsal white spots visible on dorsal mantle in some colour patterns (fig. 8a). White spots as found on arm crown never present on dorsal mantle. Distinct, but faint, patch and groove trellis present (fig. 8,b c) on dorsal and lateral mantle. Dorsal mantle often mottled with irregular darker markings. Alarm colour pattern of white mantle, dark eye bars and red arm crown and arms with prominent white spots observed in several specimens.

Skin sculpture simple, consisting of scattered low papillae evenly distributed over dorsal surfaces. Small punctae scattered between papillae on dorsal surfaces. Single slightly larger supraocular papilla directly above each eye, surrounded by low papillae. Pigmentation and sculpture do not extend to oral surface of webs.

Preserved specimens tend to lose dark red colour and definition of spots, base colour fading to cream. Pale spots containing central papilla sometimes visible on arm crown and dorsal arms. Two to three dark wavy transverse lines across dorsal arm crown often visible.

Sexual dimorphism was not marked in the material examined.

Distribution. Moderately clear waters of northern Queensland (fig. 17c). Specimens have been collected from intertidal reef flats at Lizard I.

Figure 8. *Octopus aspilosomatis* sp. nov. a, active individual on reef flats at night on Lizard I. (photograph courtesy of C.F.E. Roper). b–c, live aquarium photographs of Lizard I. specimens. d, dorsal view of preserved 67.9 mm ML male (NMV F60146), showing greatly elongated mantle. e, active individual on reef flats at night on Lizard I. f, live photograph of 42.1 mm ML male (holotype, NMV F67001). g–h, radula of 46.7 mm ML male (NMV F60144). g, dorsal view. h, lateral view.

→

(14°41′S, 145°27′E), Russell I. (17°14′S, 146°06′E) and Cape Tribulation (16°05′S, 145°29′E). One specimen was collected swimming on the surface in open water at night off Lizard I. in 25–30 m.

The distribution of this species may prove to be considerably wider, since eggs are small and hatchlings are presumably planktonic.

Life history. Nocturnally active species which forages on exposed intertidal coral reef flats in moderately clear water of the offshore islands and mainland coast of northern Queensland where coral reefs are well developed. This species occupies lairs within coral bedrock and under living coral, blocking entrance during the day with pieces of dead coral. It is unclear whether lairs are permanent or temporary refuges. No prey remains were found surrounding lairs. Animals only emerge after dark.

A total of 25 actively foraging individuals was encountered, always in less than 0.3 m on exposed reef flats. Individuals were only encountered at night between 0020 and 0535 hr, which corresponded with low tides at time of collection. No specimens were encountered subtidally, either during the day or at night.

This species preys on small crabs and other crustaceans by probing crevices and burrows with arm tips. Foraging individuals were captured carrying small crabs on suckers close to the mouth. Cannibalism is also likely to occur in the wild as several larger individuals readily attacked and commenced devouring smaller conspecifics when placed in the same container.

This species tolerates low salinities, being difficult to narcotise in freshwater. As was noted with *O. alpheus*, this tolerance may relate to the intertidal habits of this species where rain can result in temporary low salinities in closed and shallow pools at low tide.

Small eggs indicate young adopt a planktonic habit on hatching.

Several specimens contained large numbers of nematodes in the connective tissue membranes surrounding the visceral mass.

Etymology. From the Greek "*aspilos*" meaning without spots and "*soma*" meaning body, referring to the absence of red or white spots on the dorsal mantle in all colour patterns.

Remarks. Roper and Hochberg (1987, 1988) reported *O. ornatus* Gould, 1852 from Lizard I. Examination of photographs of live material forming the basis of this record, Roper and Hochberg's reference to large numbers on the reef flats adjacent to the research station, and the low hectocotylized arm sucker count (about 90, R. Toll. pers. comm.), all clearly indicate that these reports refer to *O. aspilosomatis* and not *O. ornatus*.

Octopus dierythraeus sp. nov.

Figs 9–12, 17d

Material examined. 24 individuals were encountered live at 6 sites along the Queensland coast from Lizard I. (14°40′S, 145°28′E) in the north, to Sarina Beach (21°24′S, 149°19′E) in the south. 21 were retained and are now in the Museum of Victoria. 10 additional preserved specimens were found and examined in the collections of the Museum of Victoria, Australian Museum, National Museum of Natural History, Washington, and Muséum National d'Histoire Naturelle, Paris.

Holotype: Qld: 1♂: 135.0 mm ML, NMV F67007, off W coast of Cape Yorke, Gulf of Carpentaria, 10°51′S, 140°27′E, 57 m, C.C. LU, "Susan Wright", 14 Sep 1982 (trawl, 1940–2040 hr).

Paratypes: Qld: 1♂: 59.8 mm ML, NMV F60129, Orpheus I., Cattle Bay, 18°34′S, 146°29′E, 1.5 m, M. Norman, 11 Oct 1990 (1630 hr, flushed from lair with $CuSO_4$); 1♂: 89.1 mm ML, NMV F60127, Lizard I., Watsons Bay, Coby Hole (14°40′S, 145°28′E), 16 m, M. Norman, C. Davies, 23 Nov 1989 (1100 hr, flushed from lair with $CuSO_4$); 1♀: 118.8 mm ML, NMV F60128, Sarina Beach, 21°24′S, 149°19′E,, 0.3 m, M. Norman, 16 Sep 1990 (active at 0330 hr, handnet).

Other material: Qld: 2?: 13.8, 19.4 mm ML, AM C50580, Hayman I., 20°03′S, 148°53′E, E.H. Rainford (on reef); 1♀: 20.3 mm ML, AM C159268, "near Townsville", near 19°16′S, 146°50′E, E. Worrell, Mar 1956 (in estuary); 5♂, 3♀: 25.7–80.7 mm ML, NMV F60133, Alexandra Reef (near 16°35′S, 145°30′E), 0.1–0.2 m, M. Norman, S. Troy, 17 Oct 1990 (active on reef flats between 0100–0200 hr, handnet); 2♂: 31.1, 61.1 mm ML, AM C159267, Torres Strait,

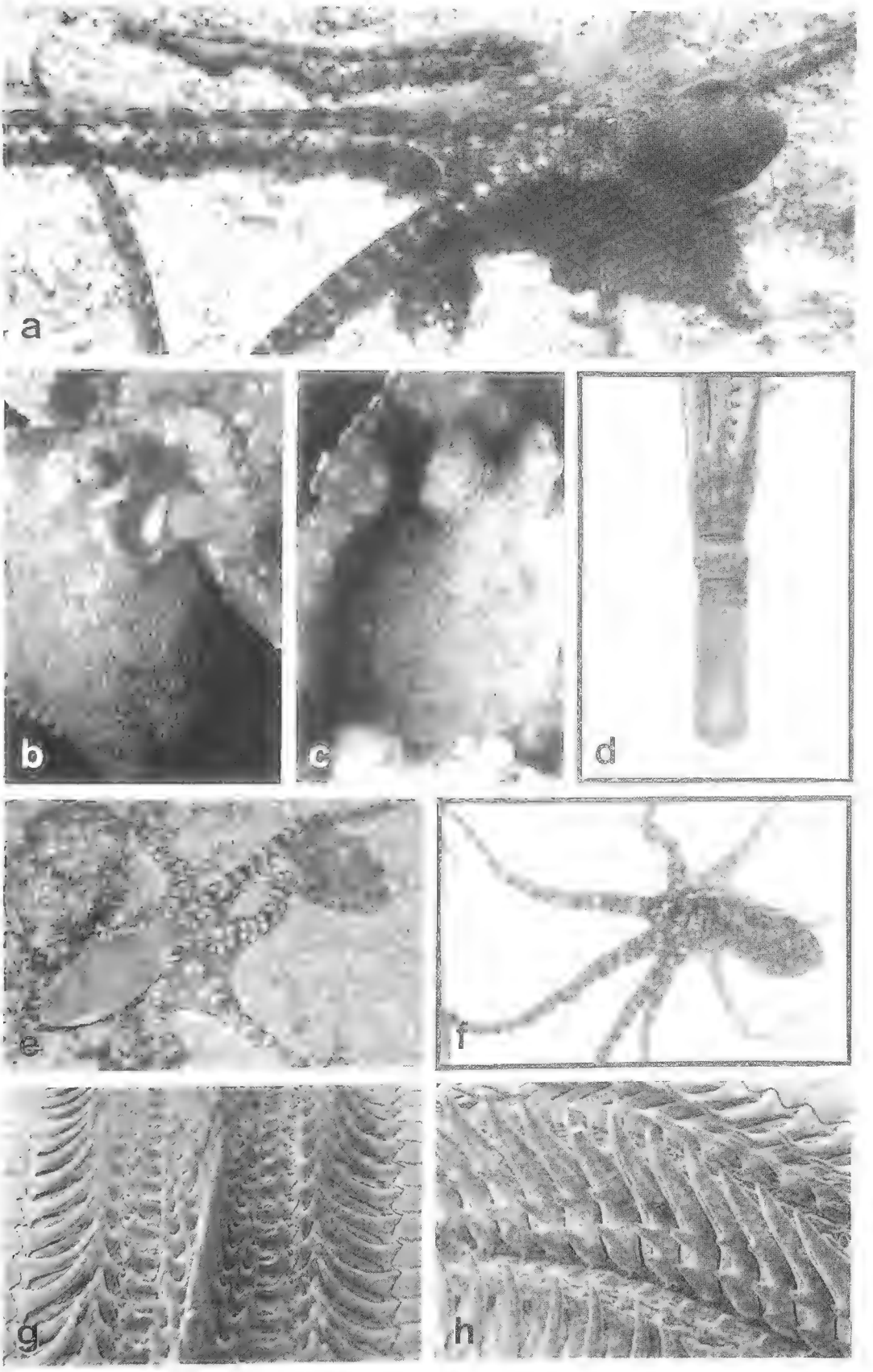

a
b
c
d
e
f
g
h

Table 4. Counts and indices for male *Octopus aspilosomatis* sp. nov.
(E = mantle considerably elongated; D = damaged; InD = indistinct; M = mature; S = submature).

Museum Reg. No.	NMV F67002	NMV F65659	NMV F67001 (Holotype)	NMV F60148 (Paratype)	NMV F60149 (Paratype)	AM C159275	NMV F60144	NMV F60146	AM C159275
ML	34.4	37.3	42.1	42.2	44.7	50.1E	51.8E	67.9E	83.2E
StM	S	M	M	M	M	S	S	M	M
TL	250	282	310	321	277	269	296	349	357
MWI	72.4	72.9	73.2	75.8	63.5	50.3	39.0	30.0	27.5
HWI	59.9	57.4	65.3	55.7	58.8	44.1	36.3	33.0	26.8
HMWI	82.7	78.7	89.3	73.4	92.6	87.7	93.1	109.8	97.4
AMI: 1	595.9	630.0	603.3	639.8	492.2	411.2	453.7	385.9	314.9
2	500.0	522.8	491.7	575.8	407.2	383.2	345.6	331.4	245.2
3	407.0	404.8	403.8	462.1	D	299.4	332.0	278.4	204.3
H	247.1	254.7	239.9	279.6	208.1	181.6	195.0	153.2	134.6
4	372.1	437.0	370.5	440.8	302.0	257.5	301.2	254.8	191.1
AWI	17.7	17.7	19.0	14.2	19.9	15.0	10.8	10.8	9.9
SDI	12.5	13.1	11.9	11.4	13.2	9.8	8.9	7.8	6.4
WDI	11.2	11.1	10.6	11.5	13.1	14.6	10.2	12.2	13.0
GC	10	11	11	10/11	10	10	10/11	10	10/11
SC	227	219	250	236	251	239	206	238	234
HAMI	247.1	254.7	239.9	279.6	208.1	181.6	195.0	153.2	134.6
OAI	60.7	62.9	59.4	60.5	D	60.7	58.7	55.0	65.9
HASC	84	78	84	81	95	92	86	80	88
LLI	5.3	6.1	6.8	7.9	7.8	4.8	4.2	8.8	7.5
CLI	24.4	29.3	20.3	20.4	19.2	20.5	23.8	22.0	15.5
TOLI	12.5	21.4	24.2	33.6	30.0	11.0	9.5	26.8	21.5
DLI	51.2	57.5	60.8	61.3	48.5	54.5	44.9	54.9	49.2
SpLI		75.1		82.9					47.8
SpWI		2.5		2.6					2.5
SpRI				54.3					46.2
SpN		1	3	2	3				3
FLI	58.1	61.1	60.3	57.1	48.8	44.3	43.1	30.9	33.7
FFI	56.0	60.1	46.1	60.6	47.2	53.6	57.4	49.5	33.9
FOI	69.4	73.2	68.1	74.3	84.0	77.7	InD	80.6	InD
FOLI	49.0	68.9	64.2	56.4	54.6	54.5	InD	66.2	InD

Table 5. Counts and measurements for female *Octopus aspilosomatis* sp. nov.
(S = submature; E = mantle considerably elongated; D = damaged; * = immature ovarian eggs; InD = indistinct).

Museum Reg. No.	NMV F67002	NMV F65664	NMV F65661	NMV F65664	NMV F65664	NMV F60144	NMV F60147 (Paratype)	NMV F60145 (Paratype)
ML	36.4	39.0	39.8	43.2	45.9	50.7E	56.8	67.1
StM	S	S	S	S	S	S	S	S
TL	243	256	219	283	318	301	314	439
MWI	51.9	52.1	45.2	48.4	45.8	43.2	50.9	49.8
HWI	51.9	41.8	47.5	39.1	41.2	41.8	47.2	39.6
HMWI	100.0	80.3	105.0	80.9	90.0	96.8	92.7	79.6
AMI: 1	535.7	530.8	424.6	532.4	568.6	469.4	438.4	527.6
2	428.6	397.4	361.8	D	481.5	410.3	345.1	D
3	368.1	346.2	304.0	D	372.5	359.0	283.5	427.7
4	326.9	305.1	238.7	331.0	372.5	335.3	267.6	357.7
AWI	16.2	11.3	13.6	12.0	11.5	11.8	13.0	13.6
SDI	9.6	7.7	8.0	6.7	8.7	9.3	8.8	9.4
WDI	11.3	10.1	12.4	9.1	10.0	11.8	14.5	10.5
GC	11	11	10	11	10/11	11	10	10
SC	234	217	228	230	236	243	246	267
ELI								1.6*
EWI								
EN								~30 000
FLI	51.6	45.1	44.0	50.0	54.5	49.3	36.8	48.7
FFI	54.3	43.2	28.6	41.2	86.8	51.6	41.6	58.1
FOI	61.9	InD	72.2	66.1	58.4	64.8	InD	78.5
FOLI	51.6	InD	51.4	53.2	45.2	51.2	InD	67.0

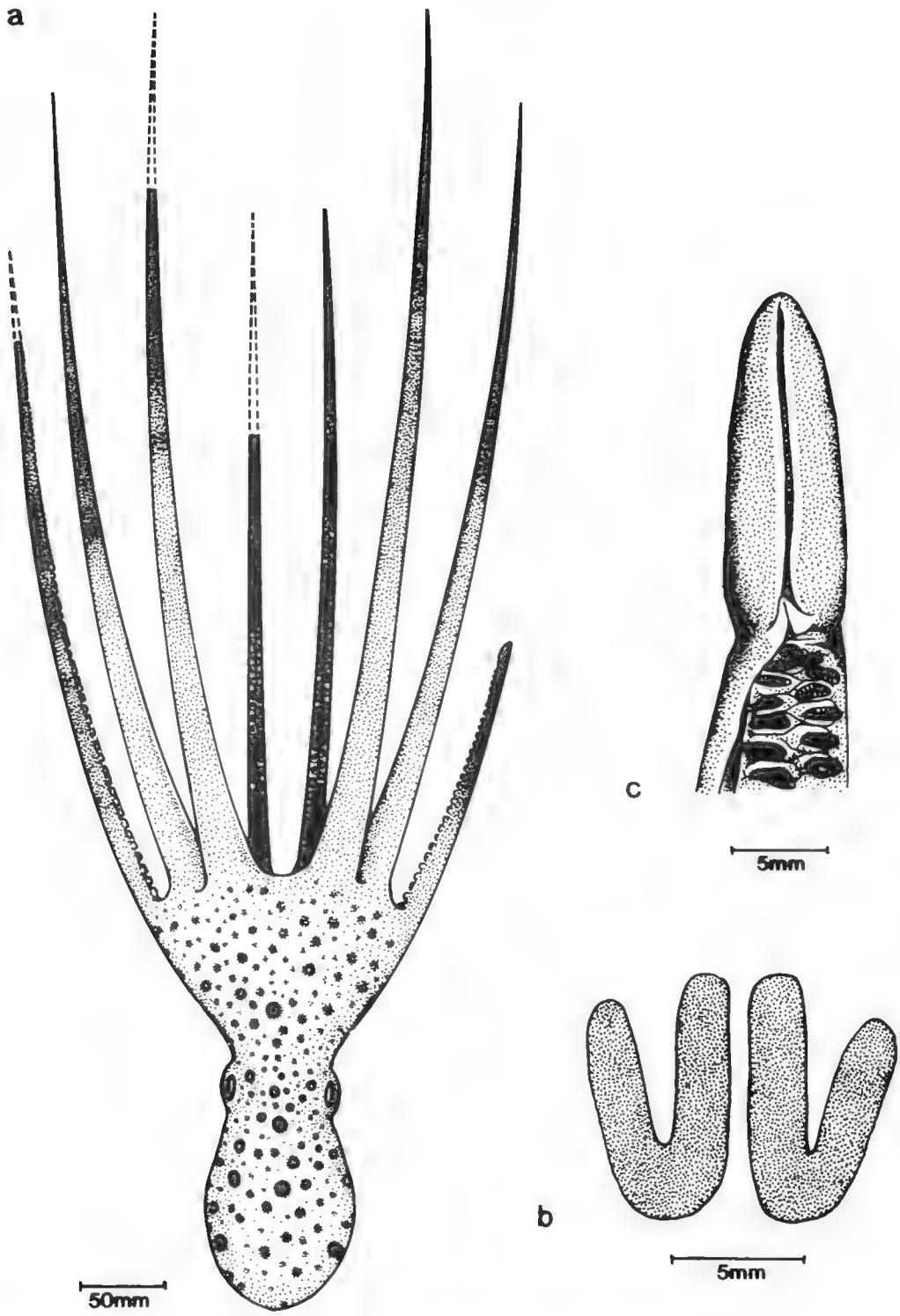


Figure 9. *Octopus dierythraeus* sp. nov. a, dorsal view of 135.0 mm ML male (holotype, NMV F67007). b, funnel organ of 37.5 mm ML male (NMV F60134). c, copulatory organ of 135.0 mm ML male (holotype, NMV F67007).

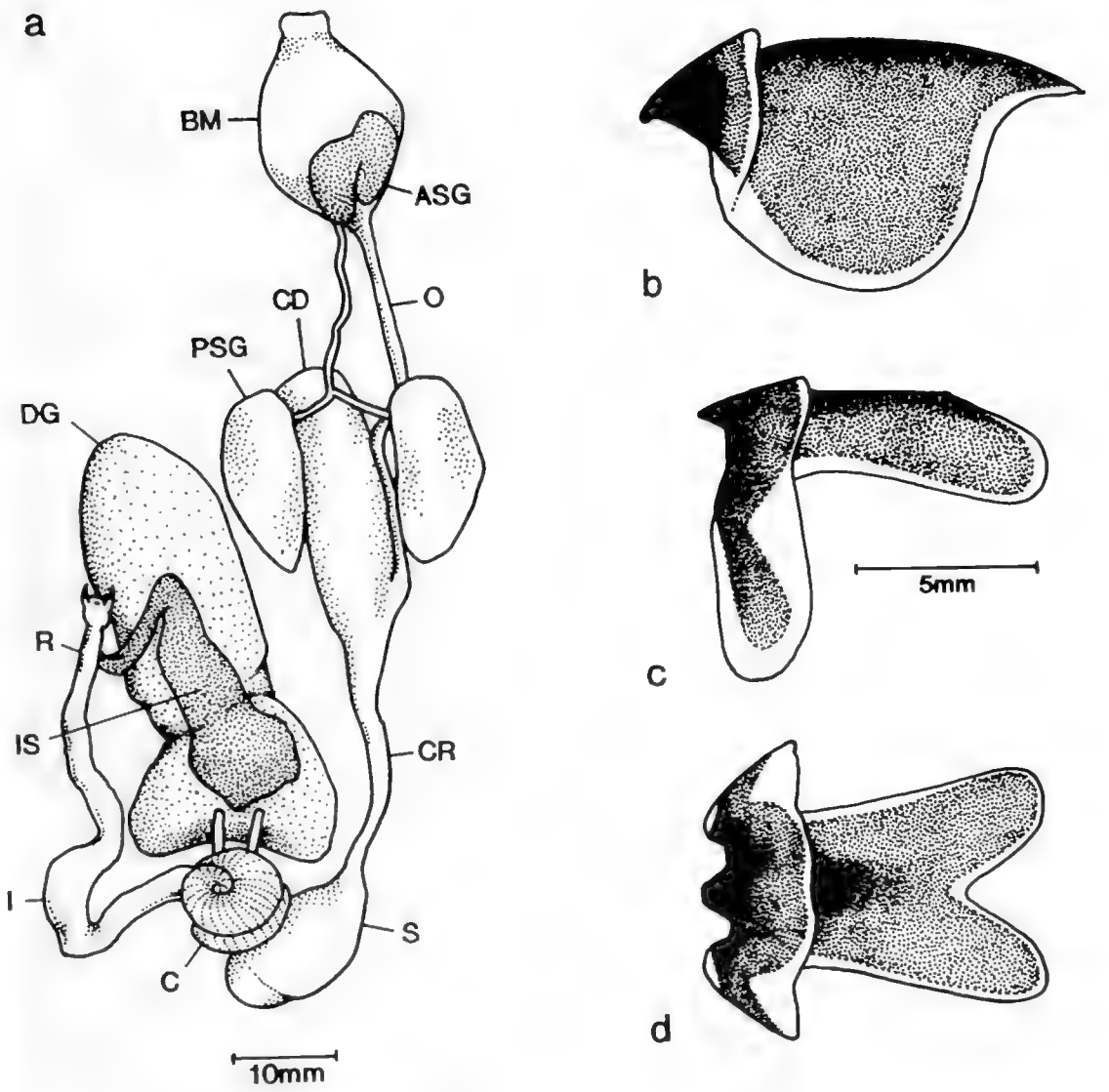


Figure 10. *Octopus dierythraeus* sp. nov. a, digestive tract of 60.7 mm ML male (paratype, NMV F60133) [abbreviations as in fig. 2a]. b–d, beaks of same specimen. b, upper beak, lateral view. c, lower beak, lateral view. d, lower beak, ventral view.

Thursday I., 10°35′S, 142°13′E, G.P. Whitley, 1928; 1♂: 35.5 mm ML, NMV F60132, Orpheus I., Pioneer Bay, 18°36′S, 146°29′E, 0.1 m, M. Norman, 6 Oct 1990 (active at 0410 hr, handnet); 1♂: 36.5 mm ML, AM C164181, Lindeman I., 20°27′S, 149°02′E, G.P. Whitley, 1935; 2♂: 37.5, 48.6 mm ML, NMV F60134, Sarina Beach, 21°24′S, 149°19′E, 0.1–0.2 m, M. Norman, 16 Sep 1990 (active between 0305–0315 hr, handnet); 1♂: 43.2 mm ML, NMV F60131, Orpheus I., Pioneer Bay, 18°36′S, 146°29′E, 1 m, M. Norman, 8 Oct 1990 (active at 2005 hr, retreated to lair, flushed with $CuSO_4$); 1♀: 43.2 mm ML, NMV F60138, Cape Hillsborough, 20°55′S, 149°05′E, 0.1 m, M. Norman, 18 Sep 1990 (in mouth of lair at 0430 hr, flushed with $CuSO_4$); 1♀: 45.3 mm ML, NMV F60136, Bowen, Cape Edgecombe, 20°01′S, 148°15′E, 0.1 m, M. Norman, 20 Sep 1990 (active at 0400 hr, handnet); 2♀: 50.5, 52.5 mm ML, NMV F60137, Magnetic I., Geoffrey Bay, 19°09′S, 146°52′E, 0.1–0.3 m, M. Norman, S. Troy, 4 Oct 1990 (active between 0230–0330 hr, handnet); 1♂: 53.1, 1♀: 77.1 mm ML, USNM 817785, Gulf of Carpentaria, off Weipa, 12°35.4′S, 141°36.2′E, 2 m, G. Hendler, "Alpha Helix" stn M-18, 4 Jun 1979; 1♀: 54.6 mm ML, NMV F60135, Magnetic I., Horseshoe Bay, 19°07′S, 146°51′E, <0.1 m, M. Norman, J. Martin, 9 Nov 1989 (within lair at 1200 hr, flushed with $CuSO_4$); 1♂: 66.6 mm ML, NMV F60130, Orpheus I., Cattle Bay, 18°34′S, 146°29′E, 1.5 m, M. Norman, 9 Oct 1990 (within lair at 1600 hr, flushed with $CuSO_4$); 1♂: 90.5 mm ML, MNHN 4.2.853, Torres Strait, Thursday I., 10°35′S, 142°13′E, M. Lix, No. 27, 1891.

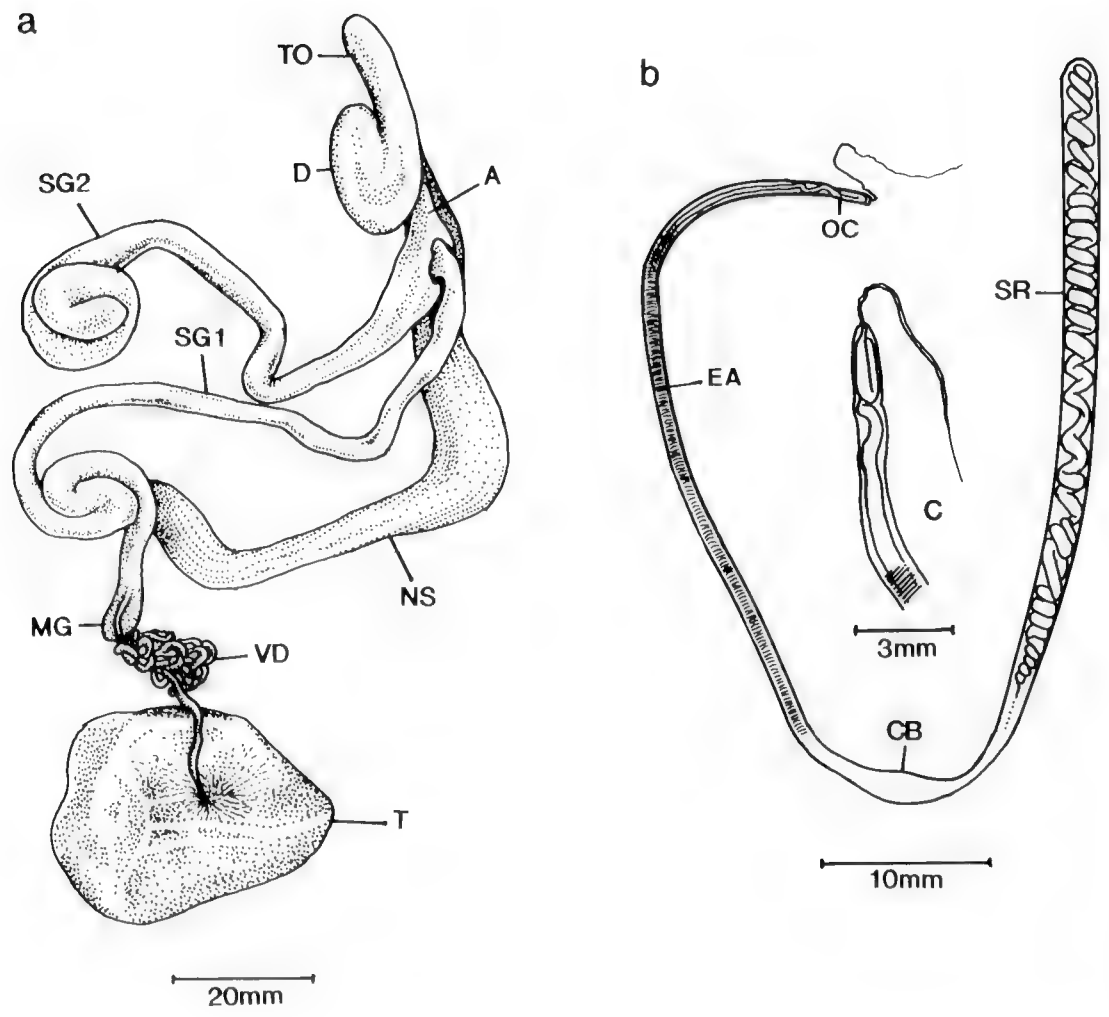
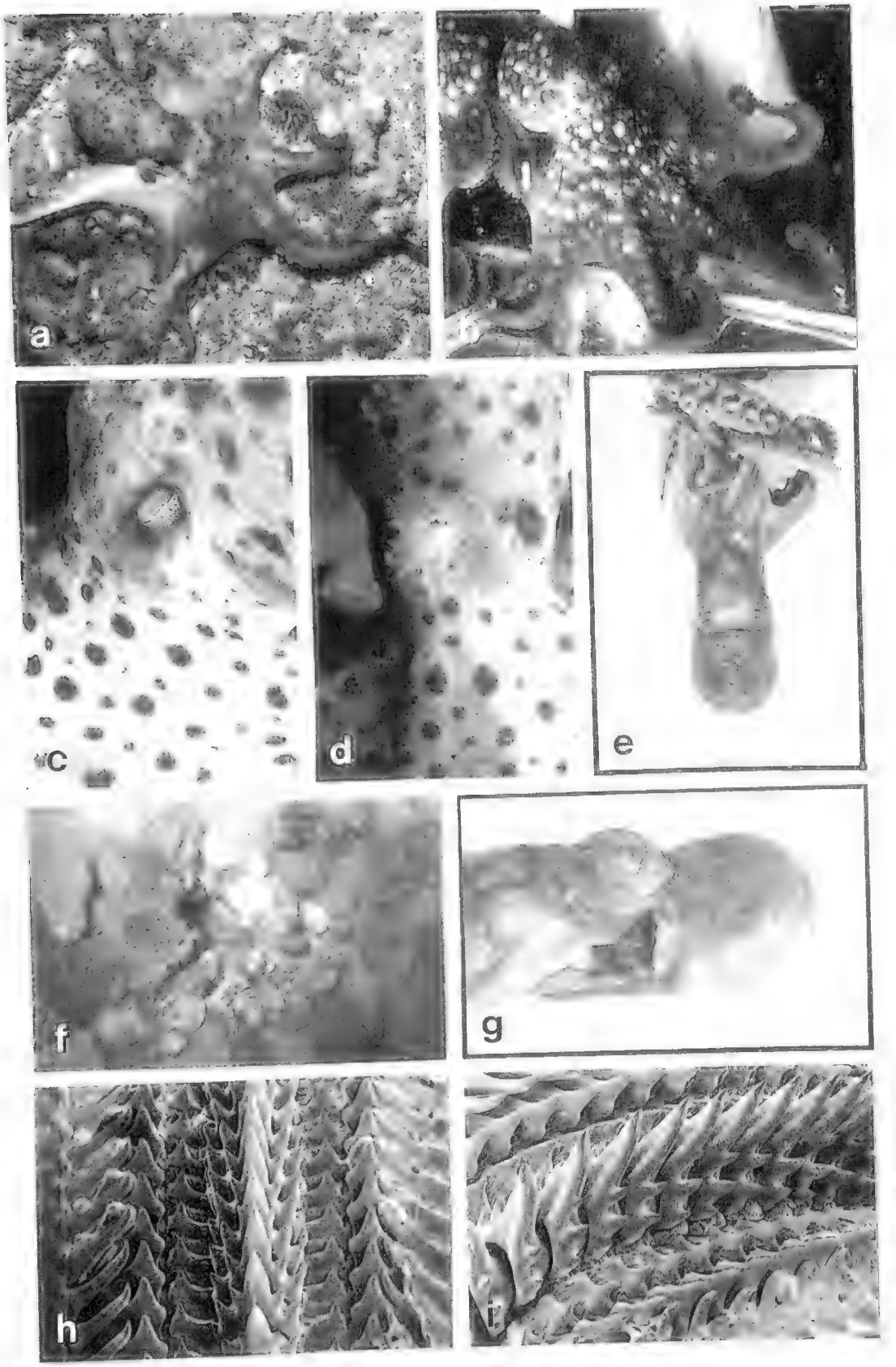


Figure 11. *Octopus dierythraeus* sp. nov. a, reproductive tract of 135.0 mm ML male (holotype, F67007) [abbreviations as in fig. 3a]. b–c, spermatophore from same specimen. b, whole spermatophore. CB = cement body; EA = ejaculatory apparatus; OC = oral cap; SR = sperm reservoir. c, detail of oral cap.

Figure 12. *Octopus dierythraeus* sp. nov. a, active individual at night on reef flat on Magnetic I., showing resting/foraging colour pattern. b, intermediate colour pattern of 54.6 mm ML female (NMV F60135), showing first signs of red spots within white spots. c, alarm colour pattern of same specimen. d, alarm colour pattern of 66.6 mm ML male (NMV F60130). e, dorsal view of preserved 59.8 mm ML male (NMV F60129). f, lair of 66.6 mm ML male (NMV F60130). g, lateral view of preserved 60.7 mm ML male (NMV F60133), showing pale spots each containing a central papilla. h–i, radula of 80.7 mm ML female (NMV F60133). h, dorsal view. i, lateral view.


a
b
c
d
e
f
g
h
i

WA: 1♂: 71.6 mm ML, NMV F67013, off Kimberley coast, 13°12′S, 125°03′E, 77–78 m, C.C. Lu, FV "Hai Kung", 30 March 1981 (on sand).

Diagnosis. Large muscular species with unequal arms, dorsal arms longest and most robust (AF 1.2.3.4), typically 4 to 5 times mantle length. Webs moderately deep, approximately 20% of length of longest arms. Sucker counts, 200–280 per arm in submature and mature animals, 100–125 suckers on intact hectocotylized arm of submature and mature males. Gill lamellae, 12–14 per demibranch, typically 13. Funnel organ UU-shaped. No mature females encountered, submature females with large-type eggs, produced in low numbers. Alarm colouration of white base colour and red circular spots on dorsal body, arm crown and arms.

Description. The following description is based on 1 mature and 5 submature males, and 1 submature/mature female and 4 submature females. Counts and indices for material examined presented in Tables 6 and 7, with data for immature specimens (4♂, 3♀).

Moderate to large robust species (fig. 9a): ML to at least 135 mm for males and 120 mm for females, TL to at least 810 mm; weight to at least 1.5 kg. Mantle from round to ovoid, never greatly elongated (MWI 62.2–*69.7*–80.3), mantle walls moderately muscular. Stylets present, poorly developed. Pallial aperture of moderate width, approximately half mantle width. Funnel long, muscular and broad based (FLI 43.6–*60.9*–72.8) with free portion usually greater than half funnel length (FFI 36.9–*56.8*–64.8). Funnel organ well developed (fig. 9b), always UU-shaped with broad limbs, outer limbs slightly shorter than median limbs (FOI 76.2–*83.6*–92.7). Funnel organ approximately 50% of funnel length (FOLI 42.2–*51.8*–62.9).

Head of moderate width (HWI 46.8–*58.6*–71.1), typically narrower than mantle (HMWI 69.3–*84.2*–107.1). Neck distinct, slightly narrower than head. Eyes large and slightly pronounced.

Arms moderate to long, dorsal pair longest and typically 4 to 5 times mantle length (AMI 365.7–*477.5*–574.0) and robust (AWI 11.3–*19.3*–25.3), roughly square in cross section and tapering evenly along length. Arms unequal in length, dorsal pair longest, ventral pair shortest (AF typically 1.2.3.4). Suckers of moderate to large size (SDI 13.0–*15.5*–20.2), deep with distinct radial cushions and scalloped outer rim, scalloping pronounced on small distal suckers. Suckers largest on dorsal arms, none especially enlarged in either sex. 200–280 suckers on intact normal arms of larger specimens (SC 234–*259*–280, n = 5♂, 3♀). Webs of moderate depth (WDI 17.6–*20.3*–27.8), deepest dorsally receding ventrally to shortest ventral web (WF typically A.B.C.D.E). Web margins extended on ventral edges of arms for most of length.

Only 1 mature male (135.0 mm ML holotype) encountered. Hectocotylized arm of holotype almost fully regenerated, opposite arm damaged. Right third arm hectocotylized and slightly shorter than opposite arm in submature specimens [OAI(submature) 69.2–*73.9*–77.0, n = 4; HAMI(submature) 234.6–*264.9*–298.2]. Copulatory organ of mature male large [fig. 9c: LLI(holotype) 6.4 on regenerating arm], roughly cylindrical with deep ligula groove and small sharp calamus [CLI(holotype) 16.6]. Spermatophore groove well developed with fine transverse ridges. Regenerating hectocotylized arm of holotype with 93 suckers, approximately 112 suckers in submature males [HASC(submature) 103–*112*–125].

Gills with 12–14 lamellae, typically 13 on each demibranch, plus small terminal lamella.

Digestive tract illustrated in figure 10a. Anterior salivary glands approximately 40% of buccal mass length. Posterior salivary glands approximately equal in length with buccal mass. Crop diverticulum well developed, approximately 70% of length of digestive gland. Stomach bipartite. Caecum clearly striated, coiled in 1.5–2 whorls. Intestine thin walled and reflexed approximately one-third from proximal end. Rectum straight and muscular. Ink sac well developed, embedded in ventral surface of digestive gland. Ink red when released by live individuals. Anal flaps present.

Upper beak (fig. 10b) with small hood and slightly hooked rostrum. Lower beak (figs 10c–d) with moderately blunt rostrum, narrow hood, widely spread wings and flared lateral walls. Ventral view of posterior margin of lateral walls deeply concave. Radula with 7 transverse rows of teeth and marginal plates (figs 12h–i). Rhachidian tooth has 2–3 lateral cusps, typically 3, on each side of large curved medial cusp. Lateral cusps typically in symmetrical seriation, although seriation asymmetrical in 1 specimen (52.5 mm ML ♀, NMV F60137). This specimen differs from other material in no other character. The symmetry of seriation does not appear fixed. In all specimens, lateral cusps migrate from lateral to medial position over 9–10 rows. First lateral teeth small and unicuspidate; second lateral teeth unicuspidate, of moderate

Table 6. Counts and indices for male *Octopus dierythraeus* sp. nov.
(D = damaged; Imm = immature; InD = indistinct; M = mature; R = regenerating; S = submature).

Museum Reg. No.	NMV F60132	AM C164181	NMV F60134	NMV F60133	NMV F60134	NMV F60129 (Paratype)	NMV F60133 (Paratype)	NMV F60130	NMV F60127	NMV F67007 (Holotype)
ML	35.5	36.5	37.5	40.9	48.6	59.8	60.7	66.6	89.1	135.0
StM	Imm	Imm	Imm	Imm	S	S	S	S	S	M
TL	212	175	192	253	250	419	351	388	568	810
MWI	70.4	51.8	80.0	79.0	67.5	80.3	67.1	63.5	66.8	62.2
HWI	56.3	56.2	60.3	62.3	50.4	68.9	62.6	54.2	53.8	50.7
HMWI	80.0	108.5	75.4	78.9	74.7	85.8	93.3	85.4	80.5	81.4
AMI: 1	439.4	361.6	384.0	491.4	397.1	561.9	489.3	453.5	512.9	477.8
2	388.7	274.0	336.0	401.0	347.7	469.9	D	391.9	431.0	448.1
3	332.4	238.4	314.7	354.5	304.5	382.9	D	324.3	382.7	D
H	276.1	200.0	250.7	254.3	234.6	275.9	298.2	250.8	264.9	203.7R
4	388.0	241.1	296.0	330.1	271.6	372.9	375.6	294.3	334.5	382.2
AWI	19.2	15.1	18.7	19.6	16.7	25.3	24.9	19.5	21.5	23.6
SDI	14.1	11.0	12.3	15.6	13.2	20.2	15.3	15.0	13.0	14.4
WDI	17.3	19.5	22.2	20.4	22.3	20.8	>16.8D	19.2	17.7	19.2
GC	12/13	12/13	13/14	12/13	12/13	D	13	13	13	13/14
SC						242	254	264	272	280
HAMI	276.1	200.0	250.7	254.3	234.6	275.9	298.2	250.8	264.9	203.7R
OAI	83.1	83.9	79.7	71.7	77.0	72.1	D	77.3	69.2	D
HASC	108	103	105	121	105	108	125	123	117	93R
LLI	1.8	InD	1.4	1.3	2.1	3.1	2.7	2.7	2.9	6.4R
CLI	27.8	InD	InD	InD	33.3	33.3	25.0	37.8	33.8	16.6
TOLI	InD	5.5	InD	InD	7.8	14.4	InD	8.6	9.7	24.7
DLI	InD	InD	InD	InD	57.9	47.7	InD	63.2	58.1	59.8
SpLI										74.8, 75.6
SpWI										1.3, 1.5
SpRI										39.6, 41.2
SpN										4
FLI	59.2	D	56.5	63.1	59.1	67.6	69.9	60.4	61.3	45.3
FFI	65.2	D	51.5	66.2	60.9	57.7	51.1	44.5	57.9	70.1
FOI	88.1	D	88.3	75.0	82.8	76.2	89.9	InD	InD	92.7
FOLI	51.9	D	44.3	41.9	50.5	45.8	42.2	InD	InD	62.9

Table 7. Counts and indices for female *Octopus dierythraeus* sp. nov.
(D = damaged; Imm = immature; InD = indistinct; S/M = submature/mature; * = measurements of immature ovarian eggs).

Museum Reg. No.	AM C159268	NMV F60138	NMV F60136	NMV F60137	NMV F60137	NMV F60135	NMV F60133	NMV F60128 (Paratype)
ML	20.3	43.2	45.3	50.5	52.5	54.6	64.6	118.8
StM	Imm	S	S	Imm	Imm	S	S	S/M
TL	131	219	324	277	286	343	365	715
MWI	95.1	64.6	75.9	69.9	68.4	77.7	73.4	67.5
HWI	87.2	69.2	71.1	51.5	49.7	62.5	54.8	46.8
HMWI	91.7	107.1	93.7	73.7	72.7	80.4	74.7	69.3
AMI: 1	492.6	365.7	574.0	425.7	417.1	498.2	439.6	482.3
2	403.9	305.6	479.0	362.4	358.1	443.2	370.0	D
3	335.0	263.9	419.4	322.8	314.3	362.6	371.5	353.5
4	305.4	250.0	401.8	308.9	310.5	357.1	331.3	340.1
AWI	21.7	24.3	11.5	18.4	17.0	14.1	11.3	19.1
SDI	15.8	15.3	17.4	13.5	12.6	17.2	14.2	15.7
WDI	24.0	27.8	18.1	18.1	18.7	18.4	21.5	17.6
GC	12/13	13	13	13	13/14	13/12	13	13
SC	234	234	250	276				
ELI								11.9*
EWI								1.9*
EN								<200
FLI	67.0	54.2	72.8	59.6	62.5	68.1	67.6	43.6
FFI	33.1	60.7	61.0	49.5	46.4	59.2	64.8	36.9
FOI	76.9	80.8	83.1	91.9	90.3	InD	84.4	78.9
FOLI	57.4	53.4	50.3	49.2	40.9	InD	51.5	57.5

length and robust; lateral marginal teeth relatively straight, short and robust; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 11a. Terminal organ in mature male of moderate length and robust [TOLI(holotype) 24.7] with robust diverticulum (DLI(holotype) 59.8). Genital aperture subterminal. Mucilaginous gland enlarged at point of attachment to vas deferens. Spermatophoric gland I narrow with large recurved coil approximately 80% along length. Spermatophoric gland II elongate and narrow with coiled tip. Spermatophores (fig. 11b–c) approximately three-quarters of mantle length (SpLI 74.8, 75.6), narrow (SpWI 1.3, 1.5) and produced in low numbers (4 in Needham's Sac of holotype). Oral cap simple bearing long cap thread. Sperm reservoir approximately 40% of spermatophore length (SpRI 39.6, 41.2), sperm cord coiled in approximately 30 whorls in best condition spermatophore.

No mature females encountered. Immature ovaries were visible in submature females, positioned on the right hand side of the septum midway along visceral mass. The ovary of the largest female (118.8 mm ML, NMV F60128) occupied approximately 20% of visceral mass and contained approximately 350 long thin immature eggs up to 14.1 mm long [ELI(Imm) to 11.9; EWI(Imm) to 1.9]. Approximately 20 follicular folds visible on immature eggs. This species clearly produces large type eggs in moderately low numbers.

Colour in life variable, 3 distinct colour patterns displayed most frequently. Foraging animals have orange base colour with mottled cream and red/brown patches (fig. 12a). Disturbed animals have red brown base colour with white circles each containing a central papilla (fig. 12b). This pattern is similar to that of *O. alpheus* (fig. 4a–c) displaying the same large transverse pair of white spots on dorsal body. This pattern is an intermediate stage in attaining the full alarm display. Alarm display of the negative pattern: white base colour and circular red spots over dorsal body, arm crown, webs and arms (figs 9a, 12c–d). Iridescent tissue layer in the skin produces an iridescent green sheen in torchlight at night.

Skin sculpture simple, consisting of scattered low papillae with smooth tips, located in the centre of white spots in intermediate colour pattern and centre of red spots in alarm pattern (figs 9a, 12c–d). Smaller punctae occur over dorsal surfaces between papillae. Single slightly larger supraocular papilla directly above each eye, surrounded by low punctae. Oral surfaces of all webs smooth and unpigmented.

Preserved specimens lose darker red colours and definition of spots, base colour fading to pink or cream. Ventral surfaces smooth and scattered with small fine chromatophores. 2–3 dark wavy transverse lines often visible across dorsal arm crown. Pale spots containing central papilla sometimes visible on mantle, especially on lateral faces (fig. 12g).

Sexual dimorphism was not marked in the material examined.

Distribution. Coastal waters and inshore islands of the Great Barrier Reef and northern Australia, from Sarina Beach (21°24′S, 149°19′E) in the south, north to Thursday I. (10°35′S, 142°13′E) and west to the Kimberley coast, northern Western Australia (13°12′S, 125°03′E) (fig. 17d). Specimens were collected from exposed intertidal reefs and subtidally to 78 m.

Life history. Octopus dierythraeus is a nocturnally active species which forages on intertidal rock and mud flats, and shallow subtidal habitats in coastal muddy waters and round inshore islands.

This species is an active predator, observed probing amongst crevices and rubble mainly with arms 1 and 2 on exposed reef flats at night. Active animals were encountered carrying fresh bivalves, crabs, a large polychaete worm and in one case a decapitated fresh octopus of indeterminate identity. Active lairs were surrounded by clean bivalve shells and carapaces of small crabs. Large strombs were also found at two lairs. One specimen flushed from a lair at Orpheus I. (66.6 mm ML male: NMV F60130) had accumulated the remains of over 100 bivalves. Only one small crab carapace was found amongst this midden. *Octopus dierythraeus* has had a significant influence on James Cook University's Giant Clam (*Tridacna* spp.) mariculture project on Orpheus I. (18°36′S, 146°29′E). The empty shells of young clams were regularly found around lairs of this species (P. Lee, pers. comm.). Captive individuals readily take frozen fish (J. Hoey, Reef Wonderland Aquarium, Townsville, pers. comm.).

Octopus dierythraeus occupies lairs amongst rocks on muddy substrates and within coral bedrock, closing the entrance during the day with pieces of dead coral. Lairs are permanent or at least long term, judging by the large number of prey remains (primarily bivalve shells) surrounding lair entrances. Animals only emerge after dark.

The large eggs of this species indicate benthic hatchlings.

Etymology. From the Greek "*dierythros*" meaning spotted with red, referring to the red spots generated in the alarm display of this species (fig. 9a, 12c–d).

Octopus graptus sp. nov.

Figs 13–16, 17e

Material examined. None encountered live in the field. 17 specimens obtained from commercial prawn trawl operators, now in the Museum of Victoria. 10 preserved specimens were found and examined in the collections of the Australian Museum, Northern Territory Museum of Arts and Sciences, and Museum of Victoria.

Holotype: Qld: 1♀: 88.8 mm ML, NMV F67006, Cleveland Bay, Townsville (19°11′S, 147°01′E), A. Cabanban, 12 Jan 1990 (trawl).

Paratypes: Qld: 1♀: 107.0 mm ML, NMV F67008, Gulf of Carpentaria, 16°09′S, 138°51′E, 32 m, QDPI, grid 6188, port stn. 8, shot 3, 12 Apr 1983 (at 0210 hr); 1♂: 111.6 mm ML, NMV F67009, 0.3 mile (0.6 km) south of Lucinda wharf (~18°32′S, 146°22′E), 15–17 m, D. Sutton, 12–18 Nov 1989 (prawn trawl on sand).

NT: 1♀: 116.1 mm ML, NTM P1478, W of Orontes Reef, off Cobourg Peninsula, 11°06.0′S, 132°04.3′E, C. Johnson, 10 Aug 1990 (trawl).

Other material: Qld: 2♂: 68.2, 76.9 mm ML, 8♀: 57.3–86.9 mm ML, NMV F67009, 0.3 mile (0.6 km) south of Lucinda wharf (near 18°32′S, 146°22′E), 15–17 m, D. Sutton, 12–18 Nov 1989 (prawn trawl on sand); 1♀: 75.6 mm ML, 1♂: 92.0 mm ML, AM C170702, W of Fitzmaurice Point, SE Gulf of Carpentaria, 17°10.5′S, 140°30.7′E, 13 m, I. Loch, Dec 1976 (trawl); 1♂: 85.4 mm ML, NMV F67012, Gulf of Carpentaria, 10°59′S, 140°29′E, stn 058, SS05/91, 29 Nov 1991 (trawl, 0400 hr); 1♀: 87.8 mm ML, NMV F67003, 50 km west of Port Musgrave, Gulf of Carpentaria, 12°07′S, 141°27′E, 36 m, C.C. Lu, FV "Susan Wright", 16 Jun 1982 (prawn trawl, 1930–2030 hr); 2♂: 23.6, 157.9 mm ML, 4♀: 104.8–190.8 mm ML, NMV F67011, East side of Cape Yorke, somewhere N of Cairns (no exact locality data), commercial prawn trawler, 1989 (purchased from Rosslyn Bay Fisherman's Co-operative); 1♂: 111.3 mm ML, AM C170701, W of Fitzmaurice Point, SE Gulf of Carpentaria, 17°12′S, 140°37.8′E, 11 m, I. Loch, Dec 1976 (trawl).

NT: 1♂: 76.3 mm ML, NMV F67004, Off Groote Eylandt, (about 14°00′S, 137°00′E), 29 Nov 1980 (prawn shot, 2400 hr).

WA: 1♀: 40.6 mm ML, NTM P015795, Joseph Bonaparte Gulf, 13°09′70″S, 128°08′50″E, 27 Jun 1990.

Diagnosis. Large muscular species with unequal arms, dorsal pairs longest (AF 1.2.3.4), typically 4.5–7 times mantle length. Webs moderately deep, approximately 20% of length of longest arm. Sucker counts, 200–280 per arm in submature and mature animals, 86–88 on hectocotylized arm of submature and mature males. Gill lamellae, 13–14 per demibranch, typically 13 on outer demibranch and 14 on inner demibranch. Funnel organ VV-shaped. Eggs large (to 28 mm long), produced in moderately low numbers (680 in mature female). Colour pattern of pale cream to pink base colour with dark pink brown irregular scribbling over dorsal mantle and arm crown.

Description. The following description based on 2 submature, 1 submature/mature and 1 mature males, and 1 mature and 4 submature females. Counts and indices presented in Tables 8 and 9.

Large robust species (fig. 13a): ML to at least 190 mm, TL to at least 1300 mm; weight to at least 4.2 kg. Mantle round to ovoid (MWI 47.4–*59.5*–76.8), mantle walls thick and muscular. Stylets well developed. Pallial aperture of moderate width, slightly greater than half mantle width. Funnel long, muscular and broad based (FLI 40.9–*50.1*–66.6) with free portion variable in length, typically around half funnel length (FFI 20.9–*51.2*–60.1). Funnel organ moderately developed (fig. 13b), VV-shaped with narrow to medium width limbs. Outer limbs considerably shorter than median limbs (FOI 56.3–*62.1*–70.4). Funnel organ approximately 40% of funnel length (FOLI 39.2–*40.8*–44.7).

Head of moderate width (HWI 33.1–*42.9*–60.2), typically narrower than mantle (HMWI 55.5–*72.2*–92.6). Neck distinct, slightly narrower than head. Eyes large and pronounced.

Arms long, typically 4.5–7 times mantle length (AMI 446.9–*537.9*–706.8). Arms robust (AWI 15.1–*19.6*–26.2), roughly circular in cross section and tapering evenly along length. Arms unequal in length, dorsal pair longest, ventral pair shortest (AF typically 1.2.3.4). Suckers large [SDI(females and submature males): 13.1–*14.5*–16.3], larger in mature male [SDI(mature male): 21.5], but no individual suckers specially enlarged. Suckers deep with moderate flared rims, fine radial cushions and scalloped outer rim. Suckers largest on dorsal arms, none especially enlarged in either sex. Approximately 240 suckers per intact normal arm in both sexes (SC 194–*240*–280). Webs moderately deep (WDI 16.4–*20.0*–22.0), deepest dorsally

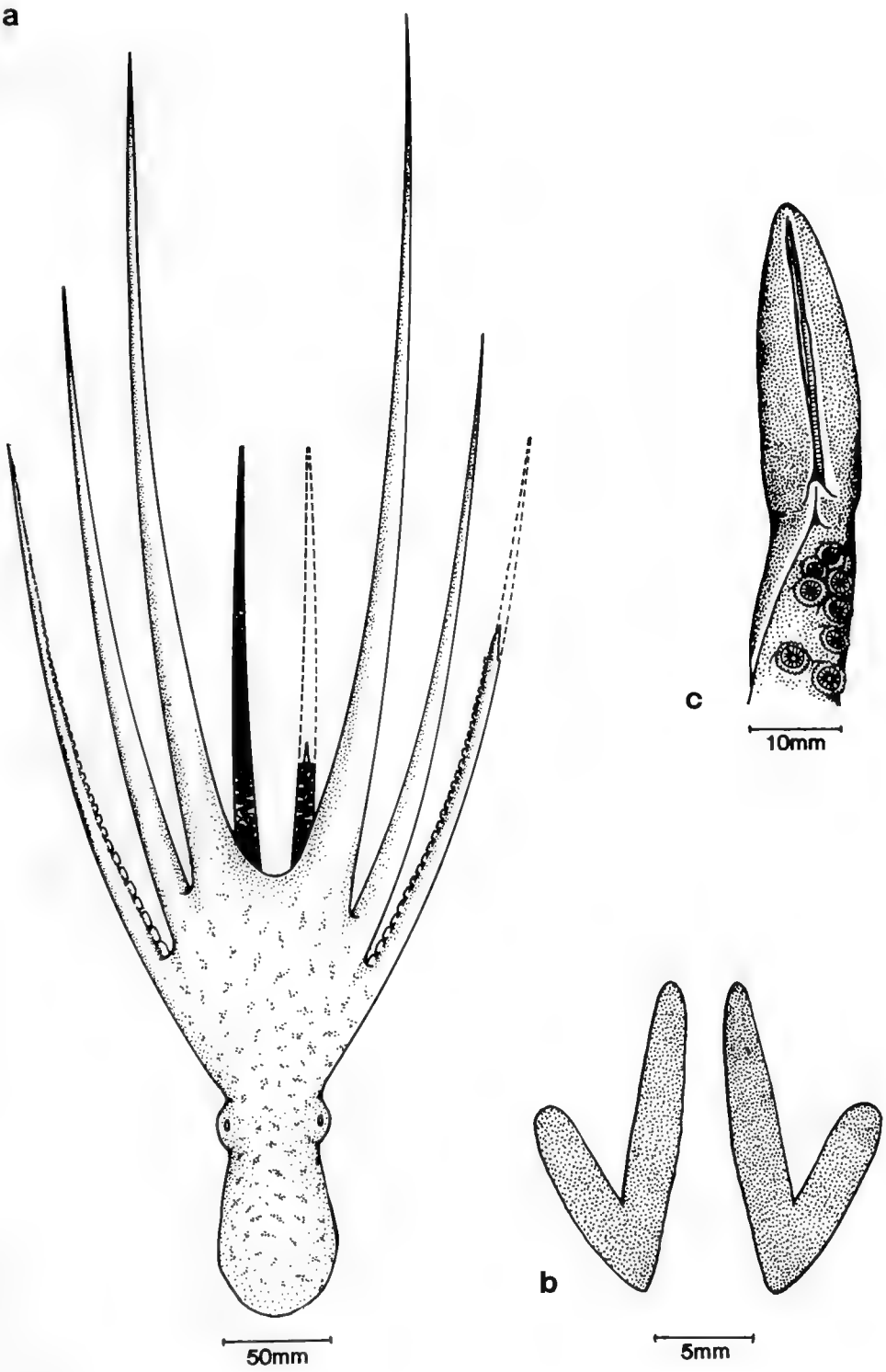


Figure 13. *Octopus graptus* sp. nov. a, dorsal view of 88.8 mm ML female (holotype, NMV F67006). b, funnel organ of 87.8 mm ML female (NMV F67003). c, copulatory organ of 157.9 mm ML male (NMV F67011).

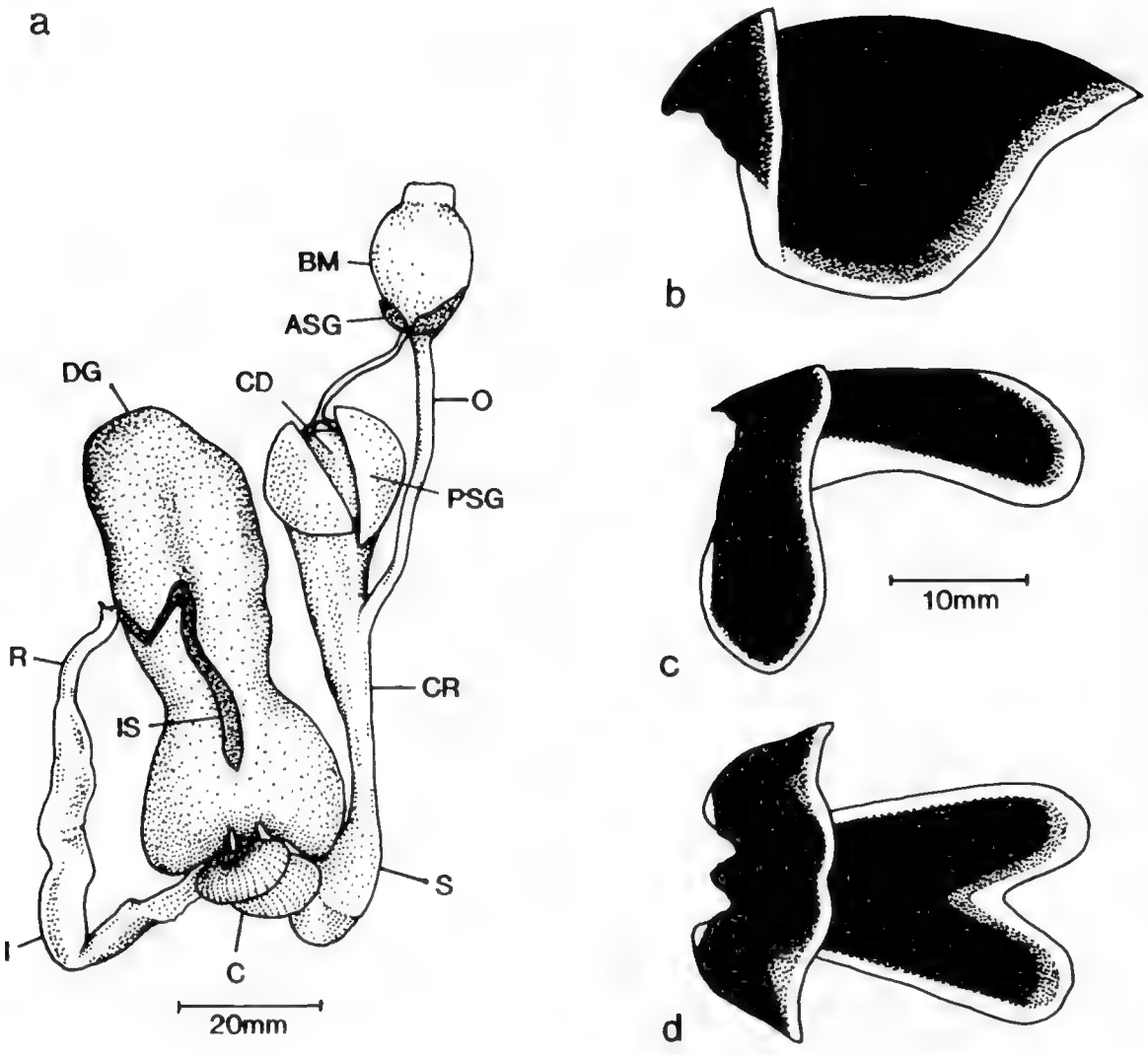


Figure 14. *Octopus graptus* sp. nov. a, digestive tract of 87.8 mm ML female (NMV F67003) [abbreviations as in fig. 2a]. b–d, beaks of 157.9 mm ML male (NMV F67011). b, upper beak, lateral view. c, lower beak, lateral view. d, lower beak, ventral view.

decreasing evenly in depth to ventral web (WF typically A.B.C.D.E). Web margins extended on ventral edges of arms for majority of length.

Right third arm in males hectocotylized, slightly shorter than opposite arm (OAI: 59.2–*68.4*–73.0; HAMI: 187.4–*265.7*–365.4). Copulatory organ (fig. 13c) of moderate size [LLI(mat) 6.5], roughly cylindrical with ligular groove deep and closed. Calamus of moderate size [CLI(mat) 19.9]. Spermatophore groove well developed and wide with fine transverse grooves. Spermatophore guide not distinct in frozen mature male. Approximately 87 suckers on hectocotylized arm (HASC 86–*87*–88).

Gills with 13–14 lamellae on each demibranch, typically 13 on outer and 14 on inner demibranch. Terminal lamella small.

Digestive tract illustrated in figure 14a. Anterior salivary glands approximately one-third of buccal mass length. Posterior salivary glands approximately equal in length with buccal mass. Crop diverticulum well developed in the specimen dissected. Stomach bipartite. Caecum clearly striated, coiled in 1.5–2 whorls. Intestine thin walled, reflexed in proximal third. Rectum muscular and straight. Ink sac poorly developed and elongate, ink duct long. Fine elongate anal flaps present.

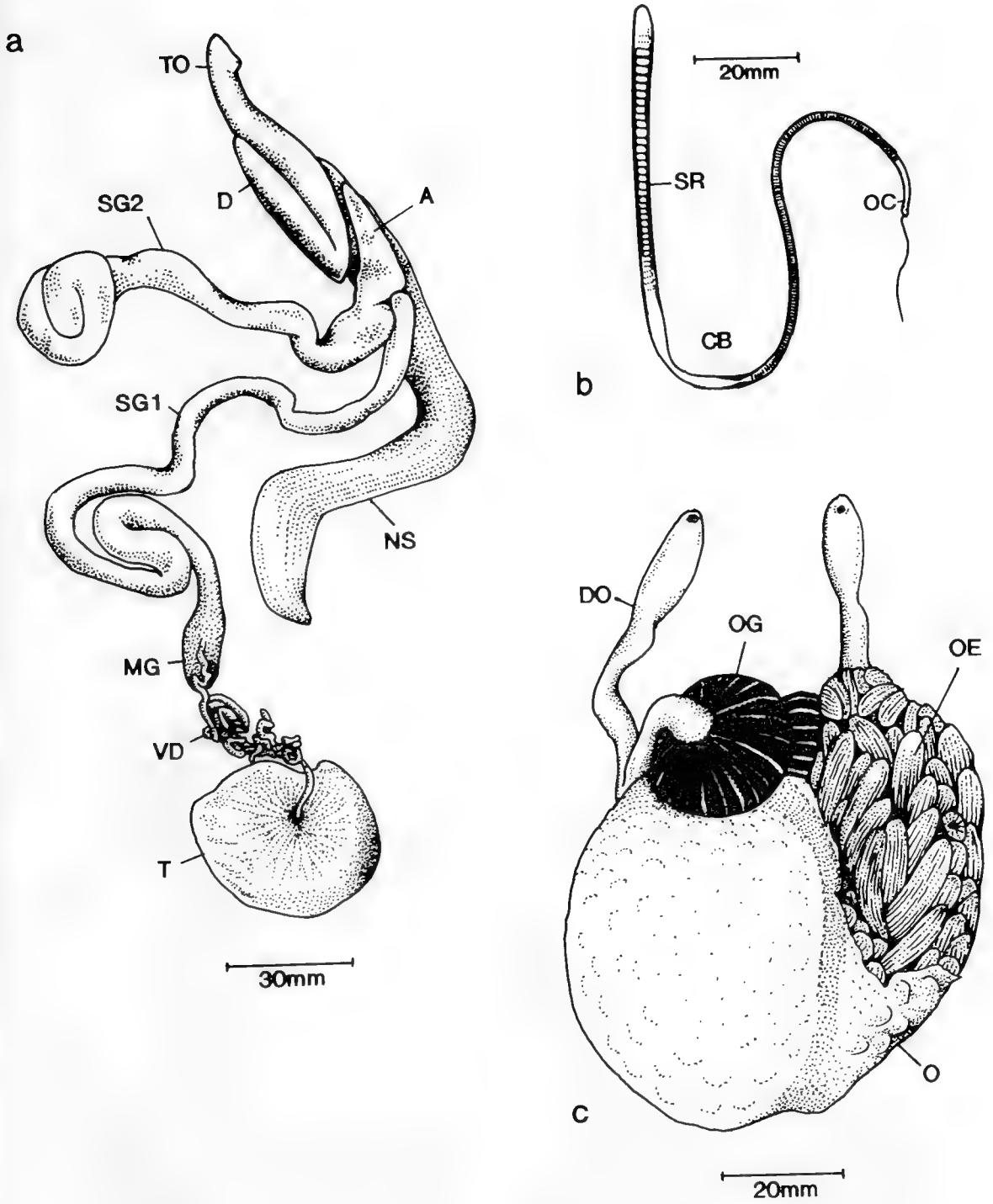


Figure 15. *Octopus graptus* sp. nov. a, reproductive tract of 157.9 mm ML male (NMV F67011) [abbreviations as in fig. 3a]. b, spermatophore from same specimen. CB = cement body; EA = ejaculatory apparatus; OC = oral cap; SR = sperm reservoir. c, ovary of 190.8 mm ML female (NMV F67011). DO = distal oviduct; O = ovary; OE = mature ovarian egg; OG = oviducal gland.

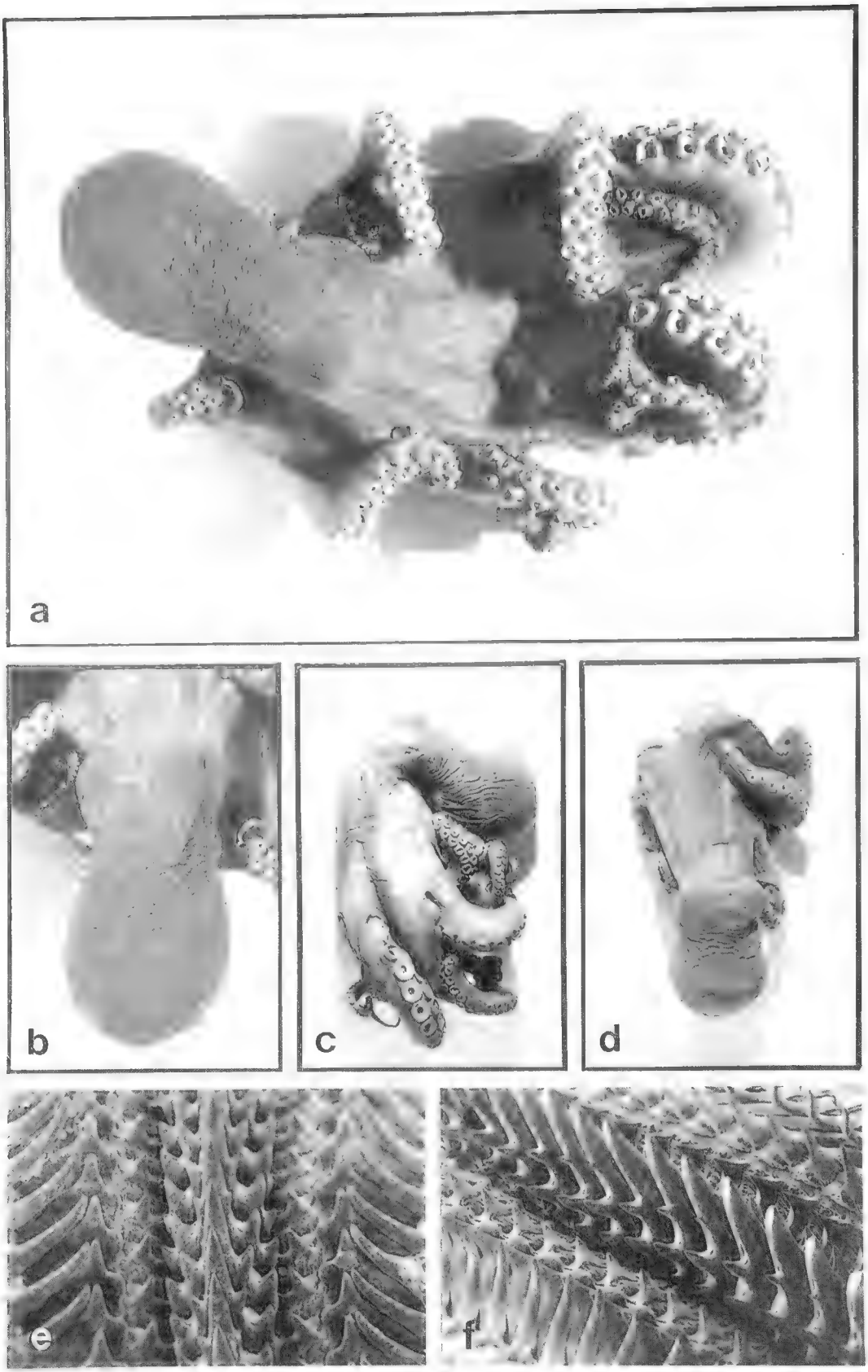

a
b
c
d
e
f

Figure 16. *Octopus graptus* sp. nov. a, dorsal view of preserved 88.8 mm ML female (holotype, NMV F67006). b, dorsal mantle of same specimen. c, lateral view of preserved 116.1 mm ML female (NTM P1478). d, dorsal view of preserved 40.6 mm ML female (NTM P015795). e–f, radula of 57.3 mm ML female (NMV F67009). e, dorsal view. f, lateral view.

Upper beak (fig. 14b) with weakly hooked rostrum, small hood and large lateral walls. Lower beak (figs 14c–d) with sharp rostrum, narrow hood, widely spread wings and flared lateral walls. Ventral view of posterior margin of lateral walls deeply concave. Radula with 7 transverse rows of teeth and marginal plates (figs 16e–f). Rhachidian tooth has 2–3 lateral cusps, typically 3, on each side of large curved medial cusp. Lateral cusps in symmetrical seriation, migrating from lateral to medial position over 9–10 rows. First lateral teeth small and unicuspidate; second lateral teeth unicuspidate, of moderate length and robust; lateral marginal teeth curved and relatively fine; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 15a. Terminal organ in mature male large and

Table 8. Counts and indices for male *Octopus graptus* sp. nov. (D = damaged; InD = indistinct; M = mature; S = submature).

Museum Reg. No.	NMV F67004	NMV F67009 (Paratype)	NMV F67011	NMV F67005
ML	76.3	111.6	123.6	157.9
StM	S	S	S/M	M
TL	420	778	749	1286
MWI	47.7	65.9	61.0	76.8
HWI	35.9	36.6	35.0	60.2
HMWI	75.3	55.5	57.3	78.4
AMI: 1	446.9	562.7	D	706.8
2	327.7	465.9	484.6	589.6
3	256.9	337.8	449.8	526.9
H	187.4	243.7	266.2	365.4
4	249.0	330.6	368.9	499.7
AWI	15.1	17.6	20.2	26.2
SDI	13.1	14.3	16.3	21.5
WDI	22.0	19.1	D	D
GC	13/14	13/14	13	14
SC	194	220	230	280
HAMI	187.4	243.7	266.2	365.4
OAI	73.0	72.1	59.2	69.4
HASC	86	86	86	88
LLI	1.5	6.1	10.3	6.5
CLI	InD	29.4	26.0	19.9
TOLI	6.0	10.7	12.1	31.2
DLI	37.0	67.2	56.4	82.4
SpLI				85.5
SpWI				1.9
SpRI				38.5
SpN				5
FLI	41.7	55.2	52.0	66.6
FFI	44.3	60.1	34.8	32.8
FOI	70.4	InD	InD	InD
FOLI	39.3	InD	InD	InD

Table 9. Counts and indices for female *Octopus graptus* sp. nov. (D = damaged; InD = indistinct; M = mature; S = submature).

Museum Reg. No.	NMV F67003	NMV F67006 (Holotype)	NMV F67008 (Paratype)	NTM P1478 (Paratype)	NMV F67011
ML	87.8	88.8	107.0	116.1	190.8
StM	S	S	S	S	M
TL	510	587	764	679	1229
MWI	59.3	58.2	56.9	60.0	49.7
HWI	47.4	53.9	41.5	42.6	33.1
HMWI	79.8	92.6	72.9	71.0	66.6
AMI: 1	479.5	542.8	574.8	455.6	534.1
2	381.5	412.2	474.8	386.7	410.4
3	325.7	346.8	396.3	288.5	370.0
4	289.3	316.4	356.1	282.5	D
AWI	15.5	18.9	21.6	21.8	19.5
SDI	13.2	14.4	15.0	14.4	15.1
WDI	21.4	19.4	16.4	21.6	D
GC	13/14	13	13/14	13/14	13/14
SC	237	225	265	258	249
ELI					14.7
EWI					17.8
EN					680
FLI	45.9	49.5	46.8	52.0	40.9
FFI	25.1	24.8	20.9	25.4	33.5
FOI	62.7	56.3	63.5	57.4	InD
FOLI	39.2	41.6	39.3	44.7	InD

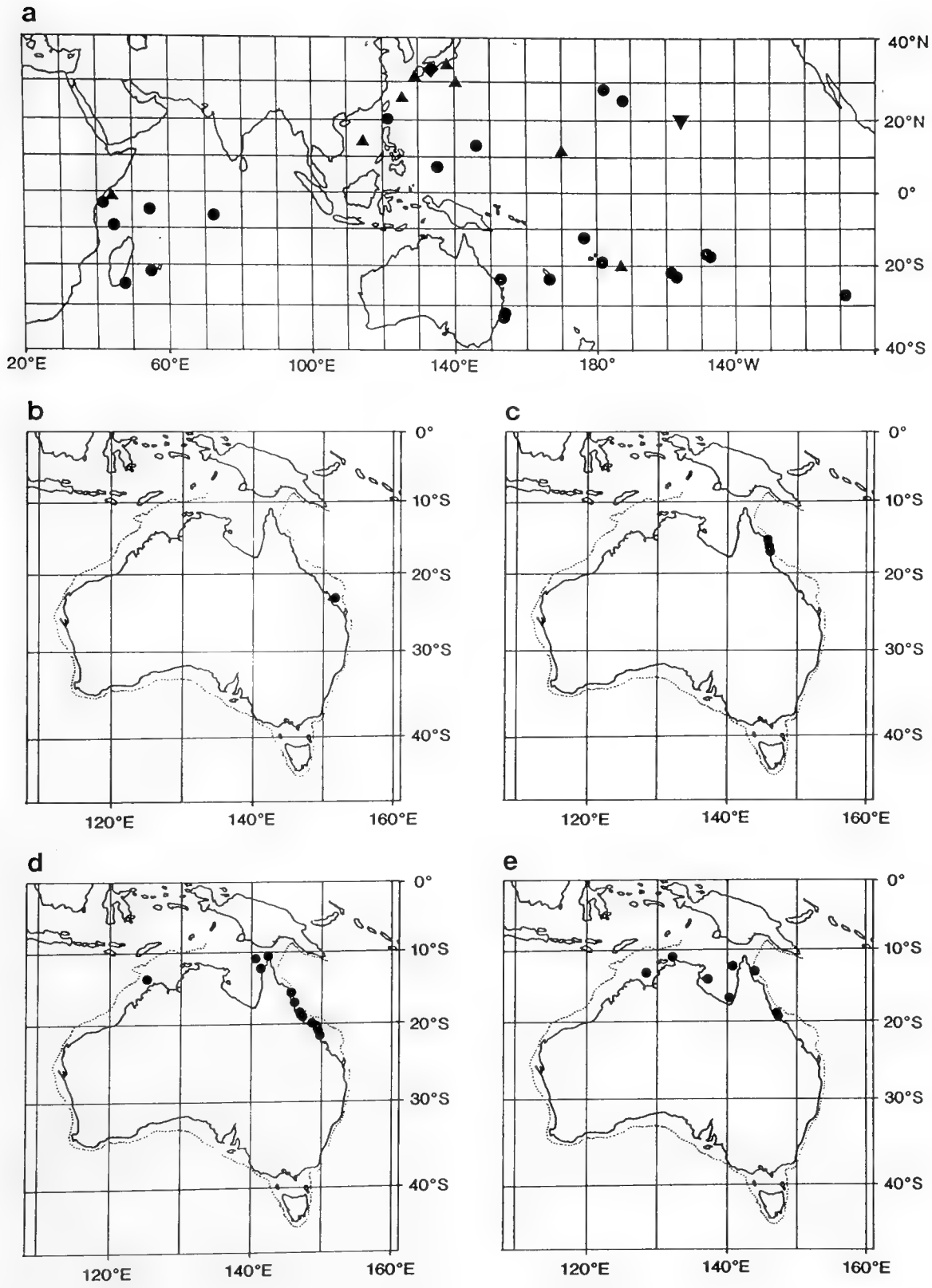
robust [TOLI(mat) 31.2] with robust diverticulum (DLI 82.4). Genital aperture subterminal. Mucilaginous gland enlarged at point of attachment to short and robust vas deferens. Spermatophoric gland I narrow and elongate with large recurved coil approximately 80% along length. Spermatophoric gland II narrow and elongate with reflexed tip. Spermatophores (fig. 15b) approximately 80% of mantle length in mature male (SpLI 85.5), of moderate width (SpWI 1.9) and produced in low numbers (5 in Needham's Sac of mature male). Oral cap simple bearing long cap thread. Sperm reservoir approximately 40% of spermatophore length (SpRI 38.5). Sperm cord deteriorated in spermatophores examined, appears regularly coiled in approximately 30 whorls in best condition spermatophore.

1 mature female specimen encountered (NMV F67011, 190.8 mm ML). Ovary contained approximately 680 almost mature ovarian eggs up to 28.0 mm long (ELI 14.7) (fig. 15c). Eggs exhibited approximately 16 follicular folds. Mature ovary bore 2 large oviducal glands with around 26 braiding chambers. Oviducts robust and relatively short.

Colour in life unknown. Preserved specimens exhibited a fixed colour pattern of cream to pink base colour with irregular fine "scribbling" over dorsal mantle and arm crown (fig. 13a, 16a, c).

→

Figure 17. Distributions of Great Barrier Reef members of the *Octopus macropus* group. a, *Octopus ornatus* Gould, 1852: ▼ = type locality; ◆ = type locality of synonym *Callistoctopus arakawai* Taki, 1964; ● = other material examined; ▲ = additional published records. b, *Octopus alpheus* sp. nov. c, *Octopus aspilosomatis* sp. nov. d, *Octopus dierythraeus* sp. nov. e, *Octopus graptus* sp. nov.


a
40°N
20°N
0°
20°S
40°S
20°E
60°E
100°E
140°E
180°
140°W
b
0°
10°S
20°S
30°S
40°S
120°E
140°E
160°E
c
0°
10°S
20°S
30°S
40°S
120°E
140°E
160°E
d
0°
10°S
20°S
30°S
40°S
120°E
140°E
160°E
e
0°
10°S
20°S
30°S
40°S
120°E
140°E
160°E

In several specimens base colour had become pink brown, darkest in distal portions of arms (fig. 16a).

Skin sculpture simple, consisting of scattered low papillae evenly distributed over dorsal surfaces. Small punctae scattered between papillae on dorsal surfaces. Single slightly larger supraocular papilla directly above each eye, surrounded by low papillae. Pigmentation and sculpture do not extend to oral surface of webs.

Sexual dimorphism was not marked in the limited material examined.

Distribution. Open substrata in the coastal waters of northern Australia (fig. 17e), from 11 to 36 m. Collected primarily in prawn trawls from Joseph Bonaparte Gulf, Western Australia (13°09'70"S, 128°08'50"E) east and south to Cleveland Bay, Townsville (19°11'S, 147°01'E).

Life history. Little is known of the life history of this species. Where time of capture information was available, all specimens were captured at night indicating that animals were emerged from lairs. This species probably has nocturnal activity patterns.

Stomach contents were examined in several specimens and were found to contain soft tissue remains, suggesting a diet of soft bodied animals such as shellfish. No crustacean or polychaete remains were found.

The large eggs produced by this species indicate that young adopt a benthic habit on hatching.

Etymology. From the Greek "*graptos*" meaning inscribed or marked, referring to the irregular "scribbled" dark markings visible on the dorsal mantle and arm crown in preserved material (fig. 13a).

Remarks. Commercial prawn trawl operators report catches of this species when trawling at night over sandy substrata. This species is figured in Queensland Department of Primary Industries posters promoting bycatch species for human consumption. Annual catch figures are not available, however it is likely that this large species makes up the bulk of the annual catch of octopuses in Queensland waters.

Discussion

These new species with other members of the *Octopus macropus* group form a distinct assembly of shallow-water octopus species exhibiting many similarities in morphology and behaviour. Shared characters include elongate arms (typically 4–7 times mantle length), dorsal arms considerably longer than ventral pair (AF 1.2.3.4), moderate to high gill lamellae counts (10–14 per demibranch), a multicuspid radula (rhachidian tooth typically bears three lateral cusps on either side of a medial cone), a moderately large cylindrical copulatory organ with deep ligula groove, forked lateral walls on the lower beak (deeply concave in ventral view), absence of enlarged suckers in both sexes, and nocturnal activity patterns.

In describing four new members of the "*Octopus macropus* group" from the tropical Indo-West Pacific, it is necessary to compare these taxa with related species already described from these waters. Table 10 lists ten nominal taxa from the tropical Indo-West Pacific which share these characters and hence are considered members of the *O. macropus* group. Except for *O. ornatus*, little has been published on these taxa, most of which are known only from their original descriptions. Based on examination of type material for seven of the nominal taxa, and counts and measurements provided in original descriptions, the new species described here can be clearly delineated.

Three of the new species (*O. alpheus*, *O. dierythraeus* and *O. graptus*) lay large eggs (to 28 mm long) in low numbers. This egg size and number indicate that hatchlings adopt benthic habits on hatching. This feature clearly distinguishes these three species from *O. lechenaultii* d'Orbigny, 1826 (and its synonym *O. cuvieri* d'Orbigny, 1826) and *O. luteus* Sasaki, 1929 which both lay small eggs in large numbers. The limited dispersal of the large-egg Australian species also reduces the probability of these species being synonymous with other Indo-West Pacific members of the *O. macropus* group, especially species such as *O. rapanui* from Easter I.

Octopus ornatus and *O. aspilosomatis* are small-egg species whose planktonic hatchlings would be capable of wider dispersal. *O. ornatus* is delineated from the other taxa listed in Table 10, primarily on the grounds of high sucker counts, high gill count (13–14 per demibranch) and its distinctive colour pattern (see Norman, in prep.).

Octopus lechenaultii (and its synonym *O. cuvieri*) is known only from the original type material. This species shows some similarities with *O. aspilosomatis* including small eggs and short webs. *O. aspilosomatis* appears distinct, however, in possessing shorter arms (AMI to

Table 10. Nominal taxa described from tropical Indo-West Pacific waters belonging to the *Octopus macropus* group.

Species	Type locality	Nature of type material
Valid taxa:		
* *O. lechenaultii* d'Orbigny, 1826	Pondicherry, Southern India	Reasonable condition (MNHN).
Synonym: * *O. cuvieri* d'Orbigny, 1826	Pondicherry, Southern India	Reasonable condition (MNHN).
* *O. ornatus* Gould, 1852	Hawaii	Good condition neotype (USNM).
Synonym: *Callistoctopus arakawai* Taki, 1964	Japan	Taki's personal collection.
* *O. rapanui* Voss, 1979	Easter Island	Good condition (USNM).
Nomen dubium:		
O. machikii Brock, 1887	Amboina, Indonesia	Very poor condition (ZMUG).
Uncertain:		
O. luteus Sasaki, 1929	Taiwan	Hokkaido Imperial Museum.
O. nanhaiensis Dong, 1976	China	Inst. Oceanol. Acad. Sin.
* *O. taprobanensis* Robson, 1926	Sri Lanka	Juvenile specimen (BMNH).
* *O. teuthoides* Robson, 1929	New Hebrides (Vanuatu)	Juvenile specimen (BMNH).
* *Eledonenta filholiana* Rochebrune, 1884	Fiji	Poorly preserved (MNHN).

* = type material examined by author

639.8 vs 669.0 for *O. lechenaultii*), slightly lower gill lamellae counts (10 vs 12 on outer demibranch) and slightly more suckers on intact normal arms (206–*235*–267 vs 168, 210). Additional material from southern India would be required to confirm this separation.

Octopus luteus has a similar morphology to *O. aspilosomatis* sharing production of small eggs. *Octopus aspilosomatis* appears distinct in having longer arms (AMI 438.3–*537.6*–639.8 vs 400, 410 for *O. luteus*), fewer gill lamellae (10 vs 12 on outer demibranch) and slightly shallower webs (WDI 9.1–*11.6*–14.6 vs 14.0, 17.7).

Octopus rapanui Voss, 1979 is described from Easter I. The type and additional specimens of *O. rapanui* were examined in the collections of NMNH and MNHN. *Octopus rapanui* is characterised by deep webs (WDI 18–23 (Voss, 1979)); about 105 suckers on hectocotylized arm; medium sized spermatophores [SpLI 66–75 (Voss, 1979)]; 11–12 gill lamellae; and distinct colour pattern of white base colour with fine purple brown chromatophores on dorsal surfaces. These characters clearly delineate this species from species occurring in Great Barrier Reef waters.

The status of some species of the *Octopus macropus* group cannot be resolved until additional material becomes available. *Octopus nanhaiensis* Dong, 1976 is known only from the brief original description based on a single male from Quangdong Province, China. The type has not been examined.

Two species are only known from juvenile specimens. *Octopus taprobanensis* Robson, 1926 was described from the pearl banks off Sri Lanka. It is known only from the type, a 14.4 mm ML specimen of indeterminate sex, which shows the characteristic arm formula (1.2.3.4) and high gill count (13). *Octopus teuthoides* Robson, 1929 was described from Vanuatu. It is known only from the type, a 15.8 mm ML specimen also of indeterminate sex, which shows the same arm formula (1.2.3.4) and slightly fewer gill lamellae (11). Until the juvenile stages of all Indo-West Pacific members of the *O. macropus* group are determined, a process commenced by Young et al. (1989) and Hochberg et al. (1992), it will not be possible to determine the status of these species.

Octopus machikii Brock, 1887 is only known from a single female type specimen. This specimen is still extant in the University Museum, Göttingen. It is in very poor condition and was considered by Pickford (unpublished MS) as being a nomen dubium. Robson (1929) described this specimen as having dorsal arms longer than ventral ones, and dorsal webs deeper than ventral ones, suggesting affinities of this species with *O. macropus*.

Rochebrune (1884) proposed a new genus and species, *Eledonenta filholiana*, on the basis of a single poorly-preserved specimen from Fiji. This genus was proposed as a new member of the Eledonidae, reported as possessing the single rows of suckers typical of the family. The type specimen of this species was examined in the MNHN and is a poorly fixed elongate specimen. The elongation of the arms has probably resulted from poor fixation or deterioration prior to fixation. The suckers are arranged in two rows but elongation of the arms has spaced suckers sufficiently for Rochebrune to interpret them as forming a zig-zag single row. *Eledonenta filholiana* belongs in the Octopodinae and is clearly a poorly preserved member of the *Octopus macropus* group. It has the characteristic arm formula of 1,2,3,4, 10 gill lamellae and a copulatory organ typical of the group. Additional, well-preserved material of this species from the type locality will be required to resolve the status of this species.

Octopus macropus has been reported a number of times from Australian waters. Girard (1890) recorded it based on a single specimen donated by Baron de Mueller, providing the locality simply as "Australia". Inadequate locality information and the absence of the original specimen leave this record unresolved. Odhner (1917) reported *Octopus cuvieri* from the tropical waters of north-west Western Australia, as "*Octopus cuvieri* d'Orbigny = *macropus* Risso, 45 miles WSW of Pearl Banks off Cape Jaubert, Western Australia". At this stage, insufficient material has emerged from the tropical waters of Western Australia to identify the octopodan fauna of this region. Hence, this record is also unresolved. Temperate Australian waters also contain members of the *Octopus macropus* group. *Octopus maorum* Hutton, 1880 (and its synonym, *O. flindersi* Cotton, 1932) from southern Australia and New Zealand waters belongs in the *O. macropus* group (for full treatment of *O. maorum*, see Stranks, 1988). An additional, undescribed species, reported as *O. macropus* by Lu and Phillips (1985), occurs in the warm temperate waters of southern Queensland and New South Wales. This species is probably the same as that reported by Brazier (1892) from Port Jackson, New South Wales under the name *O. macropus*.

The phylogenetic affinities and taxonomic status of the *Octopus macropus* group is the subject of ongoing research (Hochberg, Mangold and Norman, in prep.).

Acknowledgements

This research forms part of a PhD research program into octopods of the Great Barrier Reef and northern Australia, carried out in association with the Museum of Victoria and the University of Melbourne. Sincere thanks to C.C. Lu, F.G. Hochberg, G.F. Watson and T. Stranks for assistance with the manuscript and project; R. Toll for *O. aspilosomatis* information; C. Davies, R. Fenwick, G. Greenwood, J. Martin, J. Swartz, S. Troy, M. Turner, J. and S. Whyte and the Breidahl family for field assistance; M. Dunning (QDPI), D. Sutton and A. Cabanban (JCU) for provision of specimens; I. Loch, P. Colman and B. Rudman (AM), F. Naggs, (BMNH), T. Gosliner (CAS), R. and G. Boucher-Rodoni (MNHN), D. White and L. Vail (NTM), J. Stanisic (QM), S. Slack-Smith (WAM) and C. Roper and M. Sweeney (USNM) for assistance and access to collections; D. Paul and C. Rowley for assistance with photographic plates. This research was made possible through support grants from the Museum of Victoria, Victorian Institute of Marine Sciences, Australian Museum Postgraduate and Keith Sutherland Awards, Great Barrier Reef Marine Park Authority, M.A. Bartlett Travel Grant and Write-up Award (University of Melbourne), Joyce W. Vickery Research Fund (Linnean Society of NSW), Ethel Mary Read Fund (Royal Zoological Society of New South Wales), Ian Potter Foundation, Hawaiian Malacological Society and Royal Society of Victoria, Western Society of Malacologists, Southwest Shell Club, Santa Barbara Shell Club and San Diego Shell Club.

References

Adam, W., 1939. The Cephalopoda in the Indian Museum, Calcutta. *Records of the Indian Museum* 41: 61–110.

Adam, W., 1941. Notes sur les céphalopodes. Part XV. Sur la valeur diagnostique de la radule chez les Céphalopodes Octopodes. *Bulletin du Musée royal d'Histoire naturelle de Belgique* XVII (38): 1–19, 3 figs.

Adam, W., 1942. Les Céphalopodes de la Mer Rouge. *Bulletin of Institute of Oceanography* 822 (39): 1–20.

Adam, W., 1946. Cephalopoda from Dr. Sixten Bock's expedition to the South Pacific Islands. *Arkiv för Zoologi, Stockholm* 37A (5): 1–25, 2 pls.

Adam, W., 1954. Cephalopoda. Part 3. IV–Céphalopodes l'Exclusion des genres *Sepia, Sepiella* et *Sepioteuthis*. *Siboga-Expeditie* L (Ve): 123–193.

Adam, W., 1959. Les Céphalopodes de la Mer Rouge.

Résult scientifique de Mission de Robert Ph. Dollfus en Égypte 1927–1929 3ème partie (28): 125–193.

Adam, W., 1960. Cephalopoda from the Gulf of Aqaba. Contributions to the knowledge of the Red Sea, No. 16. *Bulletin of the Sea Fisheries Research Station, Haifa* 26: 1–26, 1 pl.

Adam, W., 1973. Cephalopoda from the Red Sea. Contributions to the knowledge of the Red Sea, No.47. *Bulletin of the Sea Fisheries Research Station, Haifa* 60: 9–47.

Berry, S.S., 1912. A catalogue of Japanese Cephalopoda. *Proceedings of the Academy of Natural Sciences of Philadelphia*: 380–444, textfigs. 1–4, pls. V–IX.

Berry, S.S., 1914. The Cephalopoda of the Hawaiian Islands. *Bulletin of the U.S. Bureau of Fisheries* 32: 255–362, 11 pls.

Boone, L., 1938. Cephalopoda, *In:* Scientific Results of the World Cruises of the yachts "Ara" 1928–1929 and "Alva" 1931–1932, "Alva" Mediterranean Cruise 1933, and "Alva" South America Cruise 1935. *Bulletin of the Vanderbilt Marine Museum* 7: 328–361.

Brazier, J., 1892. Catalogue of the marine shells of Australia and Tasmania, Part 1, Cephalopoda. *Australian Museum Catalogue* 15: 1–19.

Dong, Z., 1976. On three new species of the genus *Octopus* (Octopoda: Cephalopoda) from Chinese waters. *Studia Marina Sinica* 11: 211–215 (In Chinese).

Girard, A.A., 1890. Révision des Céphalopodes du Muséum de Lisbonne. *Journal de Sciencias Mathematicas Physicas e Naturaes* (2) 1: 233–245.

Goodrich, E.S., 1896. Report on the collection of Cephalopoda from the Calcutta Museum. *Transactions of the Linnean Society of London* Ser. 2 (Zoology) 7: 1–24, 5 pls.

Gould, A.A., 1852. Mollusca and shells. *United States Exploring Expedition . . . under the command of Charles Wilkes*, 12: i–xv, 1–510, atlas of 52 plates.

Hochberg, F.G., Nixon, M. and Toll, R.B., 1992. Order Octopoda. Pp. 213–280 in: Sweeney, M.J., Roper, C.F.E., Mangold, K.M., Clarke, M.R. and Boletzky, S.v. (eds), "Larval" and juvenile cephalopods: a manual for their identification. *Smithsonian Contributions to Zoology* 513: 1–282.

Hoyle, W.E., 1904. Report on the Cephalopoda collected by Professor Herdman at Ceylon in 1902. *Report Ceylon Pearl Oyster Fisheries, Supplementary Reports* 14: 185–200, 3 pls.

Joubin, L., 1894. Céphalopodes d'Amboine. *Revue Suisse Zoology* 2: 23–64, 4 pls.

Joubin, L., 1898. Note II: Sur quelques céphalopodes du Museé Royal de Leyde et description de trois especes nouvelles. *Notes Leyden Museum* 20: 21–28.

Lu, C.C. and Phillips, J.U., 1985. An annotated checklist of the Cephalopoda from Australian waters. *Occasional Papers from the Museum of Victoria* 2: 21–36, 1 fig.

Massy, A.L., 1916. XVI. The Cephalopoda in the Indian Museum. *Records of the Indian Museum* 12(5): 185–247, pls 23–24.

Nesis, K.N., 1982. Cephalopods of the World: squid, cuttlefish, octopuses and their allies. [1987 English abridged translation by B.S. Levitov]. T.F.H. Publication: Neptune City. 351 pp.

Norman, M.D., 1991. *Octopus cyanea* Gray, 1849 (Mollusca: Cephalopoda) in Australian waters: description, distribution and taxonomy. *Bulletin of Marine Science* 49(1–2): 20–38, 5 figs.

Norman, M.D., 1992a. *Ameloctopus litoralis*, gen. et sp. nov. (Cephalopoda: Octopodidae), a new shallow water octopus from tropical Australian waters. *Invertebrate Taxonomy* 6(5): 567–582.

Norman, M.D., 1992b. Ocellate octopuses (Cephalopoda: Octopodidae) of the Great Barrier Reef, Australia: description of two new species and redescription of *Octopus polyzenia* Gray, 1849. *Memoirs of the Museum of Victoria* 53: 309–344.

Norman, M.D., (in prep.). *Octopus ornatus* Gould, 1852 (Cephalopoda: Octopodidae) in Australian waters and a review of its description, life history and distribution. Submitted to *Proceedings of the Biological Society of Washington.*

Odhner, N.H.J., 1917. Results of Dr. E. Mjöberg's Swedish scientific expeditions to Australia, 1910–1913. Part XVII. Mollusca. *Kunliga Svenska Vetenskapsakademiens, Handlingar* (4th ser.), 52(16): 1–115, 3 pls, 51 figs.

d'Orbigny, M.A., 1826. Plates released in advance of text of Ferussac and d'Orbigny, 1835–1848.

Pickford, G.E., (unpublished manuscript). *A revision of the Indo-Malayan Octopodinae based on the collections of the British Museum.* Bingham Oceanographic Laboratory, Yale University.

Rees, W.J. and Stuckey, A., 1954. The "Manahine" expedition to the Gulf of Aqaba, 1948–1949: VI: Mollusca. *Bulletin of the British Museum (Natural History)* 1: 183–201, pls 28–30.

Robson, G.C., 1926. Notes on the Cephalopoda, I. Descriptions of two new species of *Octopus* from southern India and Ceylon. *Annals and Magazine of Natural History* (ser. 9) 17: 159–167, 7 figs.

Robson, G.C., 1929. *A monograph of the Recent Cephalopoda. I. Octopodinae.* British Museum (Natural History): London. 236 pp.

Robson, G.C., 1932. Report on the Cephalopoda in the Raffles Museum. *Bulletin of the Raffles Museum, Singapore, Straits Settlements* 7: 21–33, 4 figs.

Rochebrune, A.T. de, 1884. Étude monographique de la famille des Eledonidae. *Bulletin de la Société Philomathique de Paris* 7(8): 152–163, 1 pl.

Roper, C.F.E. and Hochberg, F.G., 1987. Cephalopods of Lizard Island, Great Barrier Reef, Australia. *Occasional Papers from the Museum of Victoria* 3: 15–20.

Roper, C.F.E. and Hochberg, F.G., 1988. Behaviour and systematics of cephalopods from Lizard Island, Australia based on colour and body

patterns. *Malacologia* 29(1): 153–193.

Roper, C.F.E. and Sweeney, M.J., 1983. Techniques for fixation, preservation, and curation of cephalopods. *Memoirs of the Museum of Victoria* 44: 29–47.

Roper, C.F.E., Sweeney, M.J. and Nauen, C.E., 1984. FAO Species Catalogue, Volume 3. Cephalopods of the World. *FAO Fisheries Synopses*, (125) 3: 196 pp, textfigs.

Roper, C.F.E. and Voss, G.L., 1983. Guidelines for taxonomic descriptions of cephalopod species. *Memoirs of the Museum of Victoria* 44: 49–63.

Sasaki, M., 1920. Report of cephalopods collected during 1906 by the United States Bureau of Fisheries Steamer "Albatross" in the northwestern Pacific. *Proceedings of the United States National Museum* 57: 163–203, 4 pls.

Sasaki, M., 1929. A monograph of the dibranchiate cephalopods of the Japanese and adjacent waters. *Journal of the Faculty of Agriculture, Hokkaido Imperial University* 20 (suppl.), 357 pp., 30 pls.

Stranks, T.N., 1988. Systematics of the family Octopodidae (Mollusca: Cephalopoda) of southeastern Australia. Unpublished MSc Thesis, University of Melbourne, Victoria. 114 pp.

Taki, I., 1944. Studies on the octopus. (2) The sexes and the reproductive organs. *Japanese Journal of Malacology (The Venus)* 13 (5–8): 267–310.

Taki, I., 1964. On eleven new species of the Cephalopoda from Japan, including two new genera of Octopodinae. *Journal of the Faculty of Fisheries and Animal Husbandry, Hiroshima University* 5(2): 277–343.

Voss, G.L., 1963. Cephalopods of the Philippines. *Smithsonian Institution Bulletin* 234: 1–180, 36 figs.

Voss, G.L., 1979. *Octopus rapanui*, new species from Easter Island (Cephalopoda: Octopoda). *Proceedings of the Biological Society of Washington* 92(2): 360–367.

Voss, G.L., 1981. A redescription of *Octopus ornatus* Gould, 1852 (Octopoda: Cephalopoda) and the status of *Callistoctopus* Taki, 1964. *Proceedings of the Biological Society of Washington* 94(2): 525–534, figs 1–3.

Wülker, G., 1913. Cephalopoden der Aru und Kei Inseln. *Abhandlungen Senckenbergischen Naturforschenden Gesellschaft* 34: 451–488, pl. XXII.

Wülker, G., 1920. Über Cephalopoden der Roten Meeres. *Senckenbergiana* 2 (1): 48–58.

Young, R.E., Harman, R.F. and Hochberg, F.G., 1989. Octopodid paralarvae from Hawaiian waters. *The Veliger* 32(2): 152–165, 5 figs.

Memoirs of the Museum of Victoria 53(2): 309–344 (1992)

OCELLATE OCTOPUSES (CEPHALOPODA: OCTOPODIDAE) OF THE GREAT BARRIER REEF, AUSTRALIA: DESCRIPTION OF TWO NEW SPECIES AND REDESCRIPTION OF *OCTOPUS POLYZENIA* GRAY, 1849

By Mark D. Norman

Invertebrate Zoology, Museum of Victoria, 285 Russell Street, Melbourne, Vic. 3000, Australia

Abstract

Norman, M.D., 1992. Ocellate octopuses (Cephalopoda: Octopodidae) of the Great Barrier Reef, Australia; description of two new species and redescription of *Octopus polyzenia* Gray, 1849. *Memoirs of the Museum of Victoria* 53: 309–344.

Four species of ocellate octopuses are reported from the waters of the Great Barrier Reef, Australia. Ocellate octopuses exhibit a false eye-spot (or ocellus) on the arm crown below each eye. *Octopus polyzenia* Gray, 1849 is reported as an ocellate species for the first time and is redescribed based on examination of the type and specimens from tropical waters across northern Australia. Two new species, *O. exannulatus* and *O. mototi* spp. nov. are described and details of distribution and life history are presented. The widely distributed *O. cyanea* Gray, 1849 is the fourth ocellate species found on the Great Barrier Reef. *Octopus cyanea* shows different affinites to the other three species and may be of separate origin. A key for ocellate octopuses of Great Barrier Reef waters is provided. Delineation of Great Barrier Reef ocellate octopuses from others of the tropical Indo-West Pacific is discussed. Distribution patterns also are examined.

Introduction

Since the early 19th century, teuthologists have been familiar with ocellate octopuses, many authors discussing them in detail (Brock, 1887; Berry, 1912, 1912a; Robson, 1929; Sasaki, 1929; Adam, 1939, 1959, 1973; Pickford and McConnaughey, 1949; Voss and Solis Ramirez, 1966). Ocellate octopuses are shallow-water species characterised by the presence of a pair of dark false eye-spots (or ocelli) on the arm crown over the bases of arms 2 and 3, one below each eye. In many of these octopuses the dark ocelli each contain a fine ring of iridescent tissue, which is expressed as a brilliant metallic blue or gold ring in live animals.

Recent research into the shallow-water octopuses of the Great Barrier Reef, Australia has uncovered many octopus species (Norman, 1991, 1992a, 1992b), including four ocellate species: *Octopus cyanea* Gray, 1849, *O. polyzenia* Gray, 1849 and two new species, *O. exannulatus* and *O. mototi* spp. nov.

Octopus cyanea is a widely distributed tropical Indo-West Pacific species, found in coral reefs. It has previously been reported from Australian waters by Roper and Hochberg (1987, 1988) and Norman (1991). *Octopus polyzenia* was previously known only from the type specimen from Port Essington, Northern Territory (Gray, 1849) and a small male from Thursday I., northern Queensland (Smith, 1884). In examining these specimens in the British Museum (Natural History), it was discovered that both possess ocelli with an iridescent ring and both were mature males despite their small size (holotype: 12.3 mm ML, BMNH 1845.5.14.78 and Thursday I. specimen: 14.1 mm ML, BMNH 1882.2.23.568). An additional 14 specimens were found in Australian museum collections (NTM, AMS, WAM, NMV). *Octopus polyzenia* is here redescribed as a small ocellate species which lays large eggs and occurs in coastal waters across northern Australia. Species accounts are presented for two new ocellate species, *O. exannulatus* and *O. mototi*, along with information on distribution, life history and live animal attributes.

Material and methods

Field work on the Great Barrier Reef was carried out between May and November in 1989 and 1990. Live specimens of *O. cyanea* and *O. mototi* were encountered in the field during the day and at night on intertidal reef walks, snorkel and SCUBA dives and caught in octopus pots in deeper water. Individuals were observed in situ, collected, photographed, narcotised in fresh water, and fixed and preserved according to the techniques of Roper and Sweeney (1983). These specimens are now in the Museum of Victoria

(NMV). Preserved specimens of all four ocellate Reef species were found and examined in the collections of the Australian Museum, Sydney (AM), Queensland Museum, Brisbane (QMB), Northern Territory Museum of Arts and Sciences (NTM), Western Australian Museum (WAM), National Museum of Natural History, Washington (USNM), Californian Academy of Science (CAS), British Museum (Natural History) (BMNH) and Muséum National d'Histoire Naturelle, Paris (MNHN).

In the description and tables, measurements and indices follow Voss (1963) and Roper and Voss (1983). Terminology has been modified by Hochberg and Mangold (in prep.) for several anatomical structures: "copulatory organ" replaces the term "hectocotylus" and "terminal organ" replaces the term "penis". The following additional or slightly modified indices also are employed:

Stage of Maturity (StM): Immature (I: sex indeterminate or reproductive organs minute), Submature (S: reproductive organs distinct but poorly developed) and Mature (M: developed spermatophores or eggs distinct); Head Width Index (HWI): head width as a per cent of ML; Head Mantle Width Index (HMWI): head width as per cent of mantle width; Arm Mantle Index (AMI): arm length as per cent of ML; Arm Width Index (AWI): maximum arm width at widest point on stoutest arm, as per cent of ML; Sucker Count (SC): total sucker count for the intact arm with the most suckers; Gill Count (GC): number of gill lamellae per demibranch not including the terminal lamella; Hectocotylized Arm Mantle Index (HAMI): length of hectocotylized arm as per cent of ML; Hectocotylized Arm Sucker Count (HASC): number of suckers on hectocotylized arm (see Toll, 1988); Terminal Organ Length Index (TOLI): length of terminal organ as per cent of ML; Diverticulum Length Index (DLI): diverticulum length as per cent of length of terminal organ; Spermatophore number (SpN): number of spermatophores in Needham's sac; Sperm Cord Whorls (SpCW): number of whorls in which sperm cord is coiled; Funnel Length Index (FLI): funnel length as per cent of ML; Free Funnel Index (FFI): length of free funnel portion as per cent of funnel length: Funnel Organ Index (FOI): length of outer limb of funnel organ as per cent of median limb length; Funnel Organ Length Index (FOLI): length of medial limb as per cent of funnel length; Ocellus Diameter Index (OcDI): diameter of ocellus as a per cent of ML (specified as referring to iridescent ring or entire dark web spot).

Indices are presented for both sexes combined, except where significant differences were found between the sexes (one-way ANOVA, $P = 0.05$ level). In these indices, range and mean for each sex are presented. Where ranges significantly overlap, standard deviations around the mean are also presented.

Two additional undescribed ocellate species have been recognised from northern Australian waters west of Cape York. Due to the scarcity of material and the apparent absence of these taxa from the Great Barrier Reef region, these forms have not been included in this work.

Table 8 summarises the key differences between ocellate octopuses of the Great Barrier Reef.

Key to ocellate octopuses of the Great Barrier Reef

1 Ocellus lacks iridescent ring; either simple black spot (figs 1a, 10e–f) or black spot surrounded by a fine dark outer ring (figs 1b, 2a) 2

— Ocellus consisting of dark spot containing narrow iridescent blue ring in live animal, visible as white or pink superficial ring over dark ocellus in preserved specimens (figs 1c, 6h, 14g–h) 3

2 9–11 gill lamellae per demibranch, typically 10; over 400 suckers on normal intact arms of submature and mature animals; approximately 200 suckers on hectocotylized arm; ocellus comprised of dark oval spot bound by additional thin dark ring (fig. 1b), iridescent tissue absent; dark zebra bars on ventral faces of all arms on submature and mature animals (fig. 2d); very large species (ML to 160 mm; weight to 6 kg; fig. 1h) .. .. *Octopus cyanea* Gray, 1849

— 7–8 gill lamellae per demibranch, typically 7; 120–190 suckers on normal intact arms of submature and mature animals; approximately 70 suckers on hectocotylized arm; ocellus plain black spot lacking an iridescent ring, oval shaped and clearly defined (figs 1a, 10e–f); 4 dark broad longitudinal stripes on dorsal body, continuing anteriorly on to dorsal arm crown

(figs 7a, 10a–d); moderate size species (ML to 50 mm; weight to 75 g; fig. 1f) ..... *Octopus exannulatus* sp. nov.

3 6–7 gill lamellae per demibranch, typically 6; 85–135 suckers on normal intact arms of submature and mature animals; approximately 50 suckers on hectocotylized arm; widely spaced dark transverse bars on all arms separated by approximately 3–4 suckers (figs 3a, 6d, g); pattern of faint crucifix of light patches on dorsal body (figs 3a); small species (ML to 38 mm; weight to 20 g; fig. 1a) ..... *Octopus polyzenia* Gray, 1849

— 9–11 gill lamellae per demibranch, typically 11; 143–176 suckers on normal intact arms of mature animals; approximately 100 suckers on hectocotylized arm; circular cluster of dark spots above each eye forming "flower" pattern (figs 11a, 14a); alarm pattern of dark longitudinal bars on dorsal body and arm crown over white base (figs 14b, e); well developed frontal white spot with prominent elongate papilla (figs 14a, 14d); moderate to large species (ML to 100 mm; weight to 300 g; fig. 1g) .. .. *O. mototi* sp. nov.

Octopodidae d'Orbigny, 1839

Subfamily **Octopodinae** d'Orbigny, 1839

Octopus cyanea Gray, 1849

Figs 1g, 2a–d, 15a

See Norman (1991) for full annotated synonymy. *Octopus marmoratus* Hoyle, 1885, *O. horsti* Joubin, 1898, *O. herdmani* (Hoyle, 1904), *O. cyanea* var. *gracilis* (Robson, 1928) and *Callistoctopus magnocellatus* Taki, 1964 are synonyms.

Diagnosis. Large robust species with black oval ocellus surrounded by pale ring and thin dark outer ring. Ring of iridescent tissue within ocellus absent. Dark bars on ventral surfaces of all 4 arms of larger specimens (ML > about 60 mm), forming stripes in alternation with base of suckers. 3–7 rows of cream spots on aboral arm surfaces from web margin to tips, containing small erectile skin ridges. Skin sculptured in irregular patch and groove system, 3 pronounced large circular patches on dorsal arm crown, especially in younger animals. 9–11 gill lamellae per demibranch, typically 10. More than 400 suckers on intact normal arms of submature and mature individuals, approximately 200 suckers on hectocotylized arm. Terminal organ small and fine (TOLI about 20). Spermatophores short, approximately 40% of ML and produced in large numbers (SpN >300). Eggs small, ovarian eggs to 2.7 mm [ELI(ov) to 1.7], and produced in very large numbers (EN >100 000).

Distribution. Octopus cyanea is recorded from tropical waters of northern Australia, from Moreton Bay, southern Queensland (27°23′S, 153°15′E) to Point Cloates, north-west Western Australia (22°42′S, 113°39′E). This species is widely distributed in the tropical Indo-West Pacific from Hawaii in the east to the east African coast in the west (fig. 15a).

Aspects of the life history of *O. cyanea* were treated in Van Heukelem (1983). Morphological description and observations of live Australian specimens were provided in Norman (1991).

Commercial exploitation. There is no commercial fishery for *O. cyanea* in Australian waters. The association of this species with coral and rocky reefs excludes it from trawl fisheries which work more open substrates. No small-scale local exploitation has been noted. Elsewhere throughout the tropical Indo-West Pacific, this species is commonly taken in local and subsistence fisheries (Hoyle, 1907; Berry, 1912; Sasaki, 1929; Rees, 1950; Van Heukelem, 1983; Roper et al., 1984).

Octopus polyzenia Gray, 1849

Figs 1d, 3–6, 15b

Octopus polyzenia Gray, 1849: 13. — Tryon, 1879: 122. — Cox, 1882: 787. — Smith, 1884: 34, pl. 4, figs A–A3. — Hoyle, 1886: 8, 80. — Lu and Phillips, 1985: 33.

Octopus granulatus (non Lamarck, 1798). — Brazier, 1892: 4.

Octopus rugosus (non Bosc, 1792). — Ortmann, 1891: 669. — Robson, 1929: 63, 65, 73. — Flecker and Cotton, 1955: 3.

Material examined. 16 preserved specimens including the extant type (BMNH 1845.5.14.78) examined in Australian museum collections and the British Museum (Natural History).

Holotype: NT; 1♂: 12.3 mm ML, BMNH 1845.5.14.78, Port Essington, 11°16′S, 132°09′E, presented by the Earl of Derby.

Other material: NT; 3Imm: 7.4–8.8 mm ML, NTM P1393, Port Essington, Coral Bay (11°16′S, 132°09′E), 4.5–6 m, Helen Larson, 18 Oct 1981 (poison station,

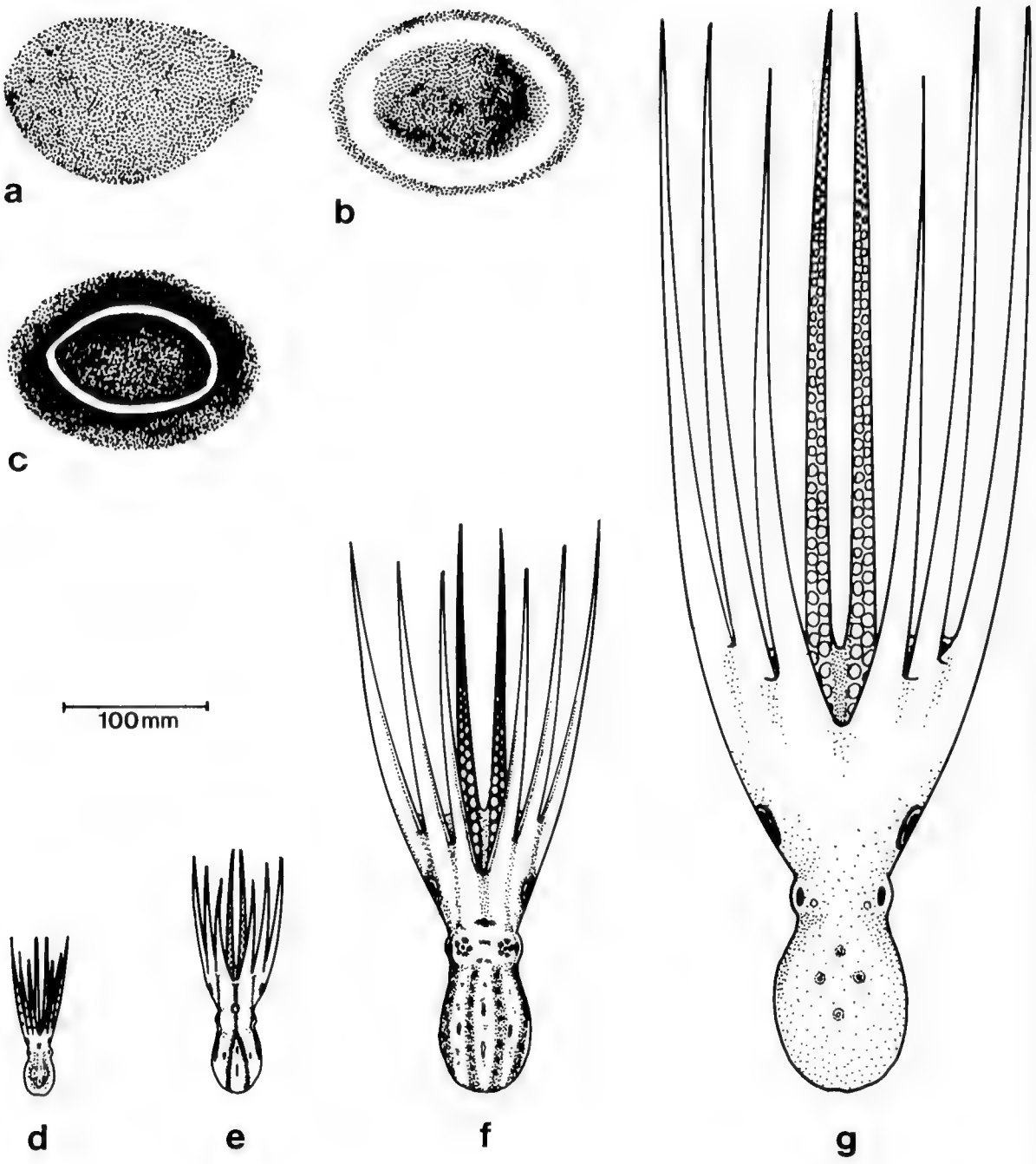


Figure 1. Ocelli and body sizes of Great Barrier Reef ocellate octopuses. a–c. Ocellus types: a, ocellus simple black spot, lacking iridescent ring or outer ring (as in *O. exannulatus*). b, dark ocellus contained within a light ring, which is bound by an additional thin black ring (as in *O. cyanea*). c, dark ocellus containing thin iridescent ring on surface of skin (as in *O. polyzenia* and *O. mototi*).
d–g. Comparative body sizes: d, *Octopus polyzenia* Gray, 1849. e, *Octopus exannulatus* sp. nov. f, *Octopus mototi* sp. nov. g, *Octopus cyanea* Gray, 1849.

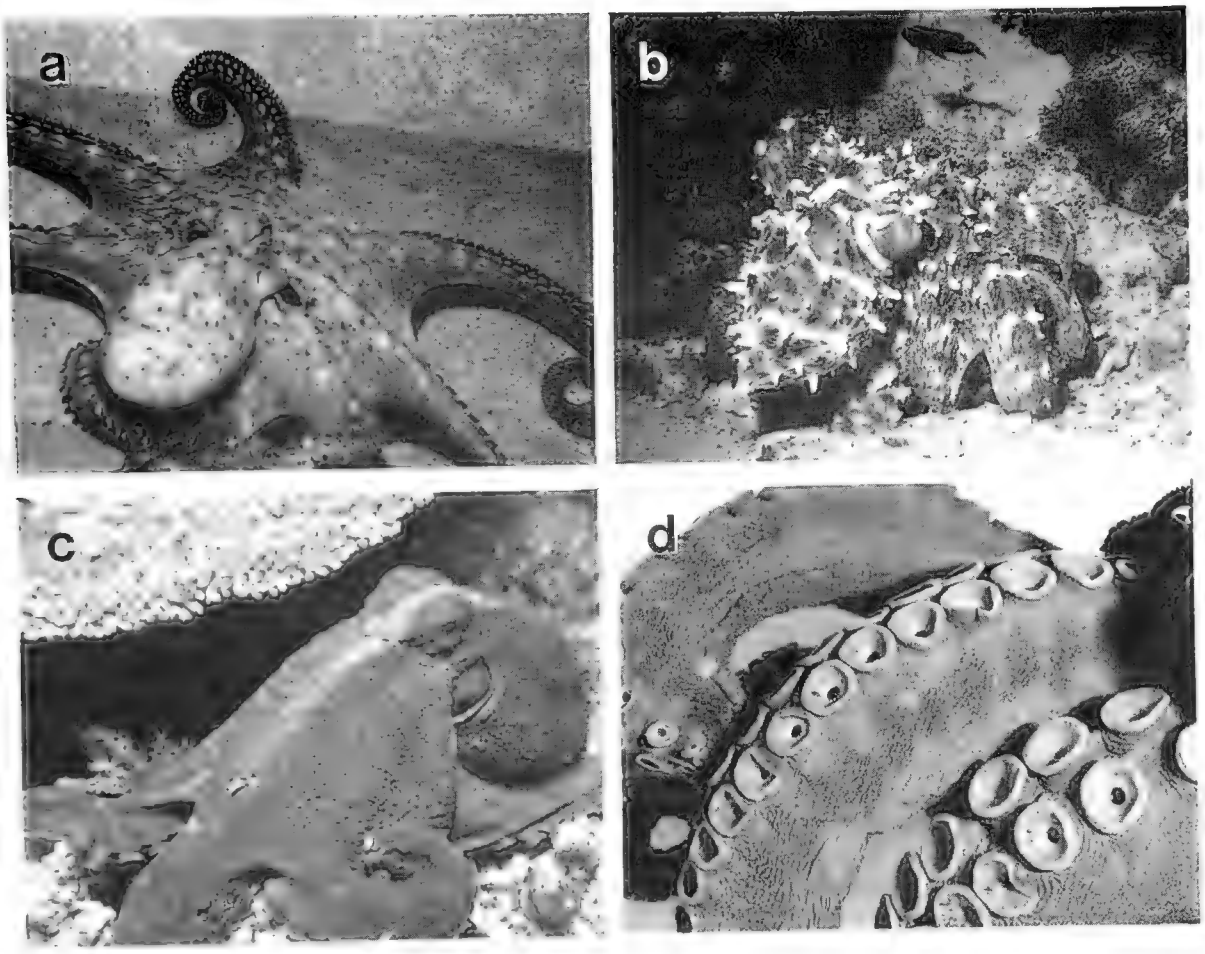


Figure 2. Photographs of *Octopus cyanea* Gray, 1849. a–c. Live colour patterns showing range in sculpture and colouration. a,warning posture with web flared and ocelli pronounced (NMV F57903: 86.7 mm ML submature female). b, "spiked" posture in wild specimen at Tryon I., southern Great Barrier Reef. c, chocolate brown colouration showing start of medial stripe in same specimen. d, dark bars on ventral arm faces of preserved specimen (NMV F57904: 100.0 mm ML mature male).

silty sand bottom, rock rubble with soft corals and gorgonians); 1♀: 32.8 mm ML, NTM P1451, Darwin, Casuarina Beach, Off Lee Point, (12°21′S, 130°52′E), C. Hood, 22 Jan 1986 (washed up in *Pinna* shell after storms).

WA: 1♀: 13.9 mm ML, WAM 363-88, Dampier Archipelago, Rosemary I., outside Norbill Bay, (20°29′S, 116°35′E), 5 m, Barry Wilson, WAM Crown of Thorns Survey, 21 May 1972 (dredged); 2♀: 17.7 mm, body missing from second specimen, ML, WAM 329-88, Dampier Archipelago, Rosemary I., Norbill Bay, (20°29′S, 116°35′E), 1–2 m, Barry Wilson, WAM Crown of Thorn Survey, 21 May 1972 (dredged on sand); 1♂: 24.4 mm ML, WAM 305-88, Monte Bello Is, northern end of Hermite I., (20°28′S, 115°31′E), F.E. Wells, 20 Aug 1986.

Qld: 1♂: 14.1 mm ML, BM 82.2.23.568, Torres Strait, Thursday I., (10°35′S, 142°13′E), 7.3–9.2 m, HMS "Alert"; 1♀: 24.9 mm ML, AM C48267, Bowen, 20°01′S, 148°15′E, E.H. Rainsford, no date; 3♀: 25.8–33.3 mm ML, AM C164168, Gulf of Carpentaria, Weipa, Albatross Bay, 12°40′S, 141°42′E, W. H. Foley, 1962; 1♂: 26.3 mm ML, AM C164179, Gulf of Carpentaria, off Karumba, (about 17°29′S, about 140°50′E), CSIRO Prawn Survey, 1963–1964 (trawl); 1♀: 37.7 mm ML, NMV F60112, Cleveland Bay, off Townsville, (19°11′S, 147°01′E), <20 m, G. Jackson, 1989 (trawled, RV "James Kirby").

Diagnosis. Small species with black oval ocellus containing an iridescent blue ring. Dark, widely-spaced, transverse bars along aboral and lateral faces of all arms, approximately 3–4 suckers between each bar. Light patches surrounding raised skin ridges form crucifix pattern on dorsal mantle. 6–7 gill lamellae per demibranch, typi-

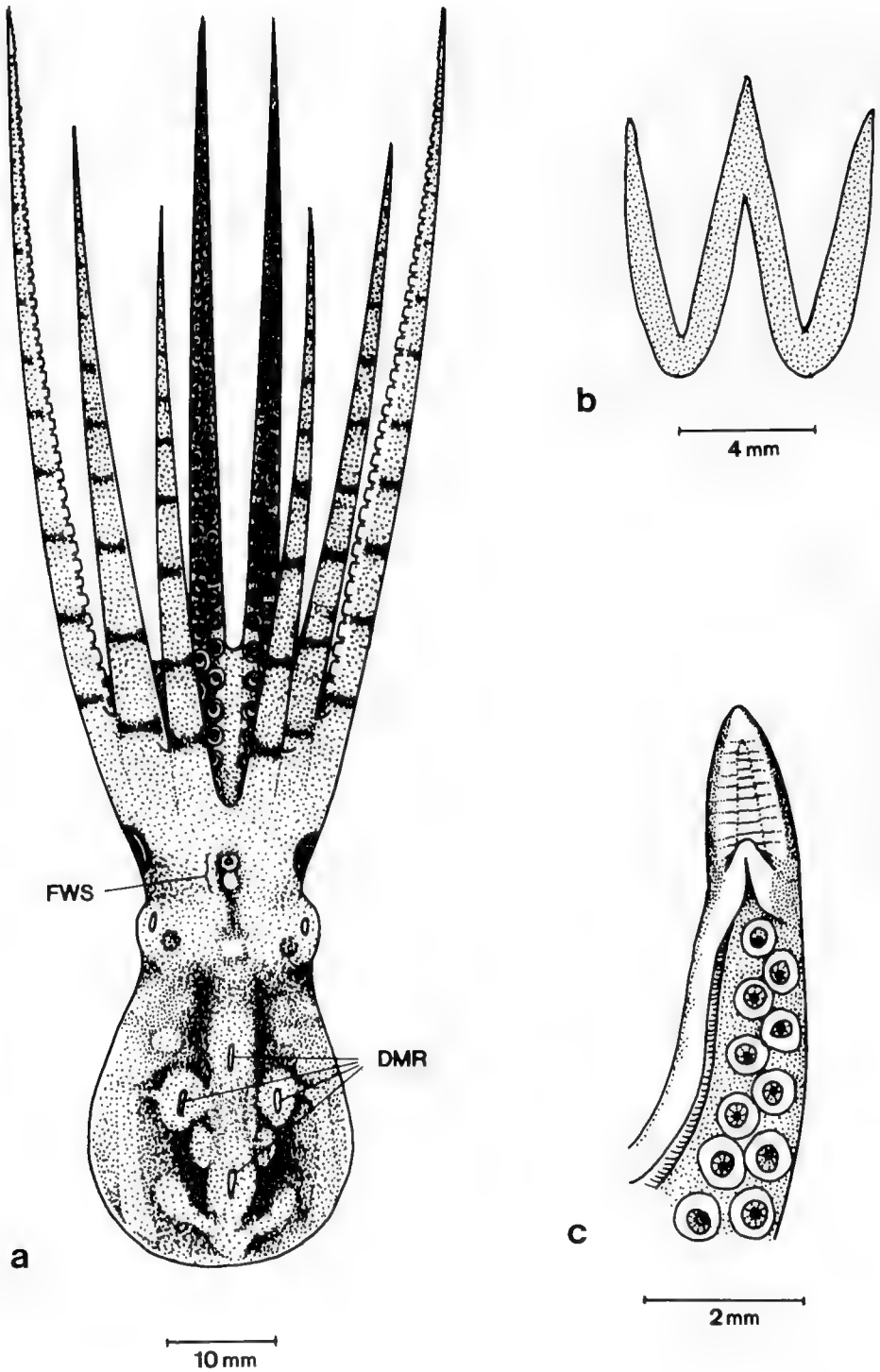


Figure 3. *Octopus polyzenia* Gray, 1849. a, dorsal view of 33.3 mm ML female (AM C164168): DMR = dorsal mantle ridges; FWS = frontal white spot complex. b, funnel organ of same specimen. c, copulatory organ of 26.3 mm ML male (AM C164179).

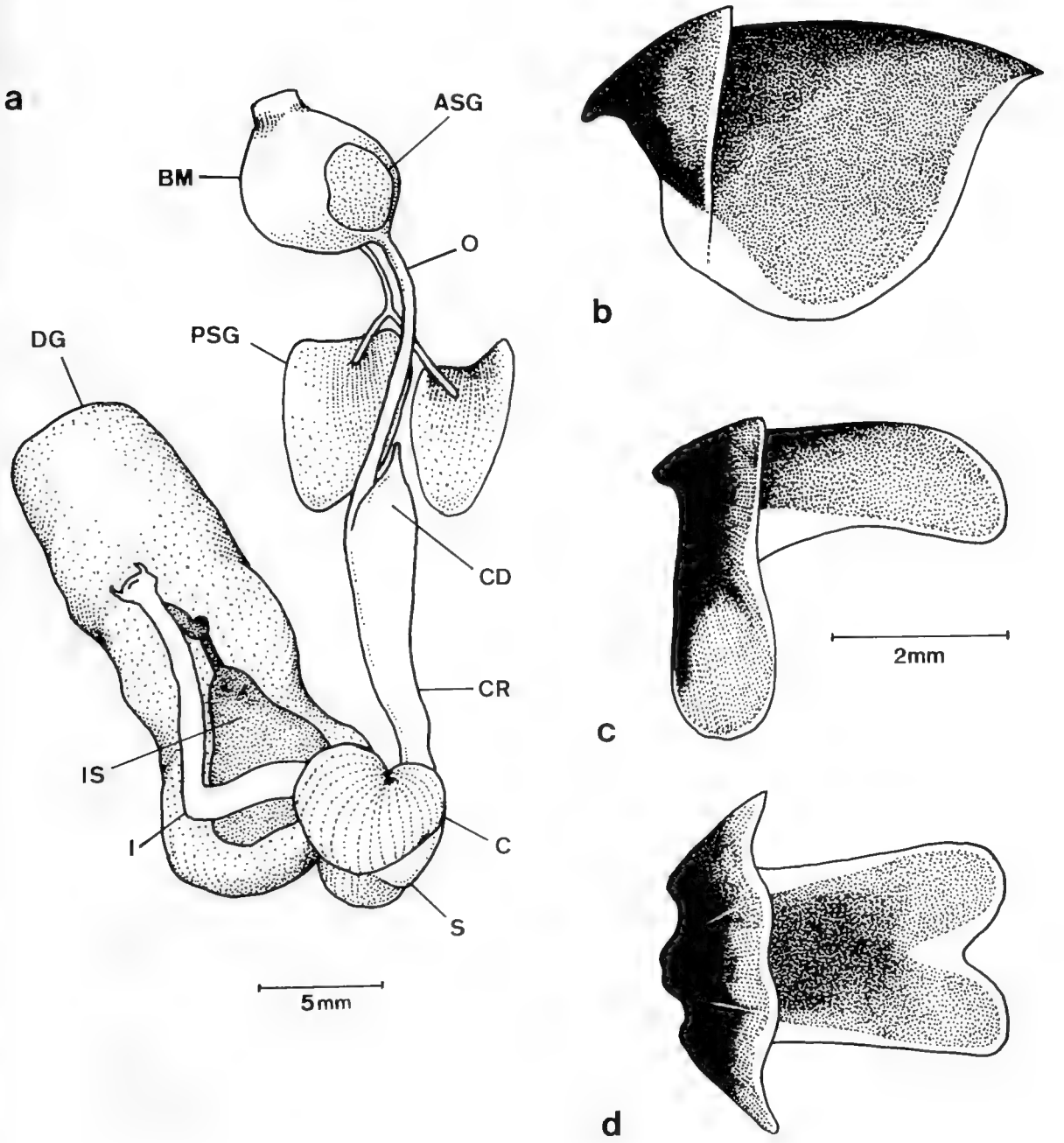


Figure 4. *Octopus polyzenia* Gray, 1849. a, digestive tract of 33.3 mm ML female (AM C164168): ASG = anterior salivary glands; BM = buccal mass; C = caecum; CD = crop diverticulum; CR = crop; DG = digestive gland; I = intestine; IS = ink sac; O = oesophagus; PSG = posterior salivary gland; S = stomach.
b–d, beaks of same specimen: b, upper beak, lateral view. c, lower beak, lateral view. d, lower beak, ventral view.

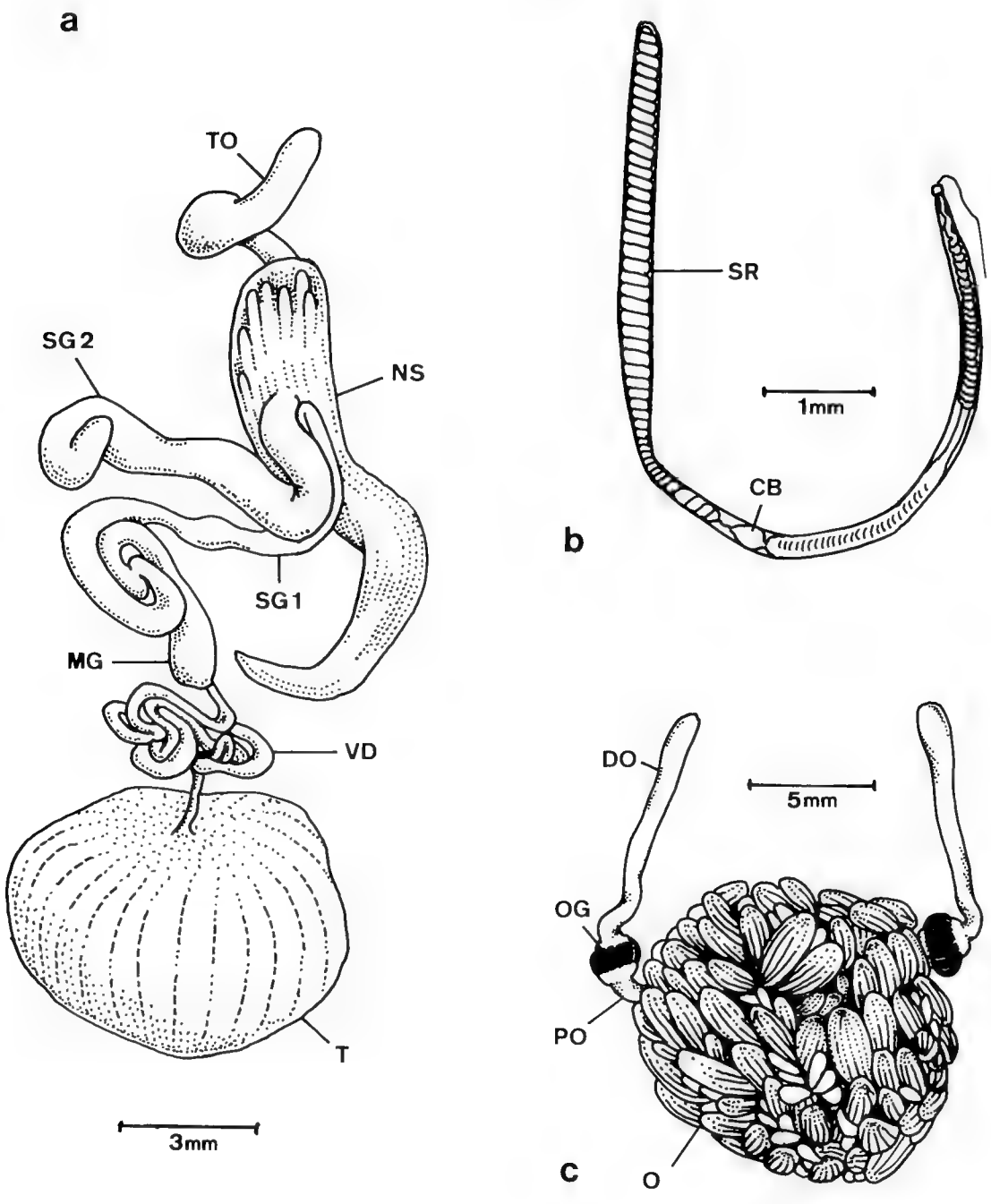


Figure 5. *Octopus polyzenia* Gray, 1849. a, reproductive tract of 26.3 mm ML male (AM C164179): MG = mucilaginous gland; NS = Needham's Sac; SG1 = spermatophoric gland I; SG2 = spermatophoric gland II; T = testes; TO = terminal organ; VD = vas deferens. b, spermatophore of same specimen: CB = cement body; SR = sperm reservoir. c, ovary of 33.3 mm ML female (AM C164168): DO = distal oviduct; O = ovary; OG = oviducal gland; PO = proximal oviduct.

cally 6. Approximately 115 suckers per arm in mature females (SC♀ 103–*115*–135, n = 9♀♀), slightly fewer in mature males (SC♂ 85, 86, 108), approximately 50 suckers on hectocotylized arm. Terminal organ short and robust (TOLI about 15). Spermatophores short, approximately one third of ML and produced in low numbers (SpN about 10). Eggs large, spawned capsules to 7.5 mm [ELI(sp) to 22.9] and produced in moderately low numbers (EN about 250).

Description. Based on 3 mature males, and 3 submature and 4 mature females. Counts and indices are in Tables 1 and 2.

Small robust species (figs 1d, 3a), males to at least 26 mm ML, females to 37.7 mm ML, TL to at least 130 mm; weight to at least 19 g. Mantle ovoid (MWI 50.4–*69.0*–85.4) with muscular walls. Stylets not found. Pallial aperture of moderate width, approximately half of mantle width. Funnel muscular and broad-based (FLI 34.1–*39.6*–51.2) with free portion usually greater than half funnel length (FFLI 44.0–*63.5*–78.1). Funnel organ W-shaped with moderate limbs (fig. 3b). Outer limbs slightly shorter than median limb (FOI 90.2–*95.1*–100.0). Funnel organ large, approximately 60% of funnel length (FOLI 48.0–*61.1*–73.5).

Head of moderate width (HWI 41.1–*49.5*–63.3), always narrower than mantle (HMWI 60.0–*72.3*–89.5). Neck distinct, slightly narrower than head. Eyes large and slightly pronounced.

Arms of moderate length, 2–3 times mantle length; from limited material arms appear slightly longer in females (AMI♂ 200.8, 209.1, 252.0; ♀ 236.4–*261.7*–309.4). Arms robust (AWI 13.0–*18.2*–25.9), roughly circular in cross section and taper evenly to fine tips. Dorsal arms shortest, lateral and ventral arms longer and more robust (AF generally 4=3.2.1 or 4.3.2.1). Suckers of moderate size, slightly elevated with distinct radial cushions and scalloped rim. Mature males can possess 1–3 enlarged suckers on all arms, beyond margin of webs at level of seventh sucker pair (SDI♂ 10.3, 11.7, 13.5; ♀ 7.7–*9.4*–12.9). Arm 4 possesses most suckers, approximately 115 suckers per arm in females (SC♀ 103–*115*–135, n = 9♀♀), slightly fewer in males (SC♂ 85, 86, 108). Webs moderate to deep (WDI 26.1–*31.4*–39.1), deepest laterally, dorsal web distinctly shorter (WF typically D.C=E.B.A or D=E,C.B.A). Web margins poorly developed, extending less than half way along ventral edge of arms.

Third right arm in males hectocotylized and slightly shorter than opposite arm (OAI: 76.9, 77.4; HAMI: 152.1, 155.7, 195.1). Spermatophore groove well developed and wide with fine transverse ridges. Spermatophore guide distinct with small papillae. Copulatory organ small and robust (fig. 3c: LLI 4.7, 5.4, 6.8), ligula roughly conical with blunt tip; groove shallow with raised longitudinal midrib. Calamus well developed and large (CLI 40.7, 44.4, 69.2). Approximately 50 suckers on hectocotylized arm (HASC: 45, 49, 52).

Gills with 6–7 lamellae, typically 6, on both inner and outer demibranchs, plus a terminal lamella.

Digestive tract illustrated in figure 4a. Anterior salivary glands moderately large, approximately half of buccal mass length. Posterior salivary glands well developed, slightly larger than buccal mass. Crop diverticulum distinct but not greatly developed. Stomach bipartite. Caecum striated, coiled in single whorl. Muscular intestine reflexed approximately one-third along length from proximal end. Ink sac well developed, embedded in ventral surface of digestive gland below iridescent tissue layer. Anal flaps present.

Upper beak with moderate hood and slightly hooked rostrum, concave on cutting edge (fig. 4b). Lower beak (figs 4c–d) with blunt rostrum, narrow hood, widely spread wings and slightly flared lateral walls. Ventral view of posterior margin moderately concave. Radula with seven teeth and two marginal plates in each transverse row (figs 6i–j). Rhachidian tooth typically has 1 lateral cusp on each side of medial cone (2 in every fourth row). Lateral cusps in symmetrical seriation, migrating from lateral to medial position over four transverse rows. First lateral teeth unicuspidate with cusp towards lateral edge; second lateral teeth unicuspidate and robust; lateral marginal teeth robust, straight and moderately short; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 5a. Terminal organ in mature males short and robust (TOLI 14.4, 16.3, 16.8) with robust diverticulum (DLI 34.2, 56.1, 70.0), genital aperture subterminal. Vas deferens short and robust. Mucilaginous gland enlarged at point of attachment to vas deferens. Spermatophoric gland I short and robust with recurved coil approximately three-quarters along length. Spermatophoric gland II relatively short and robust with reflexed tip. No distinct appendix at junction of spermatophoric glands and Need-

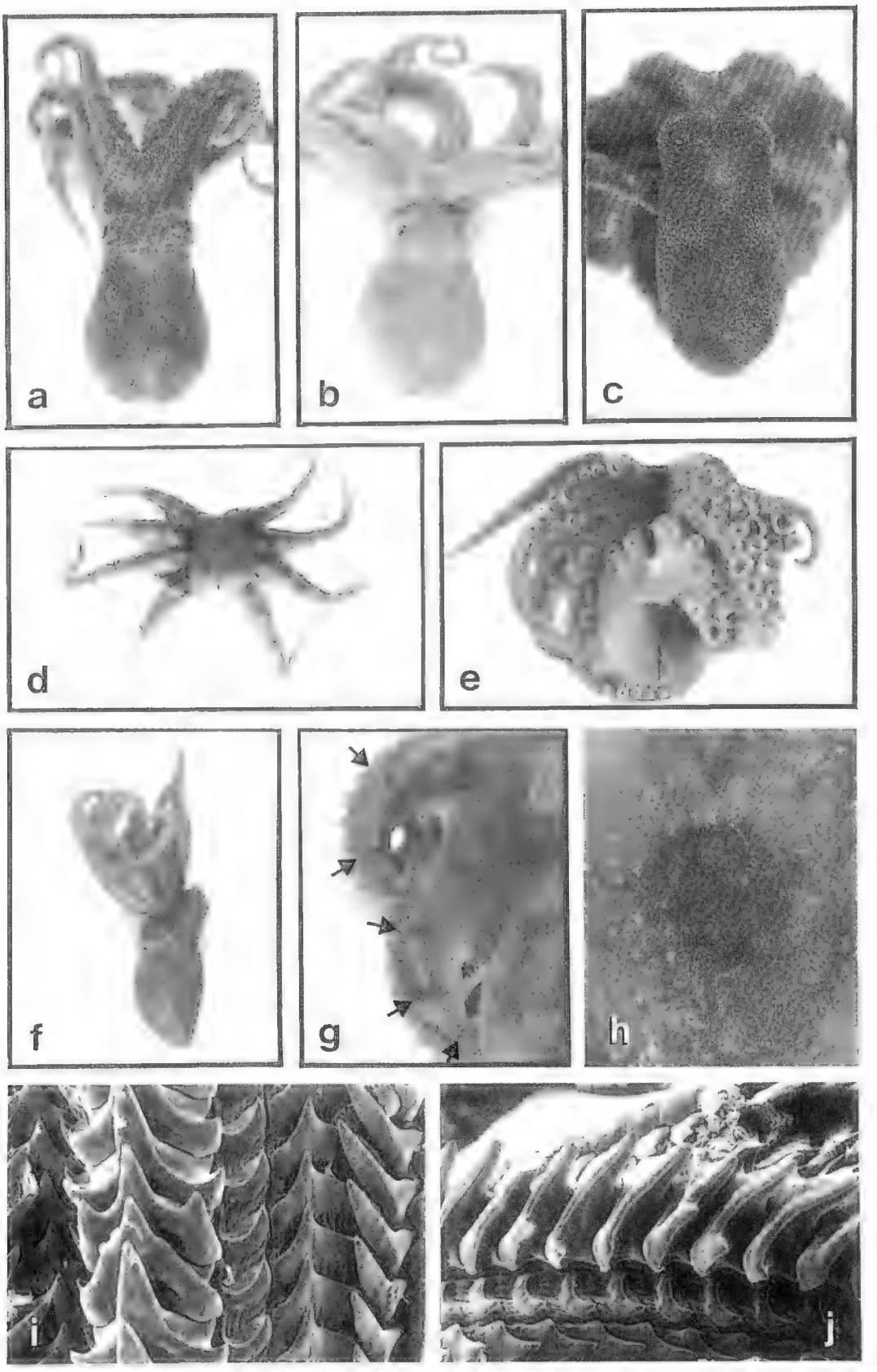

a
b
c
d
e
f
g
h
i
j

Figure 6. Photographs of preserved specimens of *Octopus polyzenia* Gray, 1849. a, dorsal view of 25.8 mm ML female (AM C164168). b, dorsal view of 26.3 mm ML male (AM C164179). c, dorsal view of 24.4 mm ML male (WAM 305-88). d, posterior view of 13.9 mm ML female (WAM 363-88), indicating arm bars. e, enlarged suckers of 24.4 mm ML male (WAM 305-88). f, lateral view of 8.8 mm ML immature specimen (NTM 1393). g, arms and ocellus of 32.8 mm ML female (NTM P1451), indicating position of arm bars. h, ocellus of same specimen, containing iridescent ring. i–j, radula of 32.5 mm ML female (AM C164168).

ham's sac. Needham's sac relatively short and robust. Spermatophores (fig. 5b) short (SpLI 34.2) and moderately robust (SpWI 5.6), produced in low numbers (10 in Needham's sac of AM C164179). Sperm reservoir approximately half spermatophore length (SpRI 55.6). Sperm cord iridescent gold in colour and coiled in approximately 45 whorls. Oral cap with constricted collar bearing long cap thread.

Mature ovary oval shaped (fig. 5c). Oviducts short, robust and straight. Oviducal glands large with approximately 14 radiating (braiding) chambers. Eggs large, capsule of mature ovarian eggs to 4.9 mm long [ELI(ovarian) to 19.7], spawned eggs with capsule to 7.5 mm [ELI(spawned) to 22.9]. Eggs moderately wide [EWI(ovarian) to 6.8; EWI(spawned) to 9.1] and produced in low numbers (226 spawned eggs accompanying 32.8 mm ML female: NTM P1451). Approximately twelve follicular folds with cross striations on ovarian eggs. Ovarian eggs in 1 female at 2 distinct stages of development, suggesting spawning over an extended period. Eggs laid in short festoons attached by short stalks to a fine central thread.

Colour in life unknown. Base colour of preserved specimens generally cream to pink brown with dark mottlings and light patches on dorsal body. Dorsal mantle pattern of light coloured oval patches containing raised skin ridges, central four arranged in diamond shape forming faint crucifix pattern (fig. 3a). Dark brown rectangular block between and slightly behind eyes in some specimens. Dark brown to black oval ocellus on either side of arm crown between bases of arms 2 and 3, containing small iridescent blue ring (fig. 6h: OcDI for iridescent ring 6.1–9.7–14.6). Dark background spot of the ocellus may fade in preserved specimens leaving only iridescent ring visible. Dark transverse bars on aboral and lateral surfaces of all arms, widely spaced with 3–4 suckers between each bar (figs 3a, 6d, f–g). No dark longitudinal line along dorsal face of arms as found in *O. mototi* and *O. exannulatus*.

Frontal white spot complex of 2 light spots present on dorsal arm crown below midpoint of eyes (FWS in fig. 3a). Anterior spot cream coloured containing primary papilla. Posterior spot pink to peach coloured, clearly distinct from surrounding pigmentation.

Body, arms and arm crown covered in small round papillae, extending on to oral surface of

Table 1. Counts and indices of male *Octopus polyzenia* Gray, 1849.
(M = mature; D = damaged; — = not recorded; * = OcDI measured as diameter of iridescent ring).

Museum Reg. No.	BMNH 1845.5.14.78 (Holotype)	WAM 305-88	AM C164179
ML	12.3	24.4	26.3
StM	M	M	M
TL	46	75	84
MWI	85.4	50.4	70.3
HWI	60.2	45.1	45.2
HMWI	70.5	89.5	64.3
AMI: 1	195.1	151.6	174.9
2	243.9	168.0	205.3
3	252.0	D	197.7
H	195.1	155.7	152.1
4	252.0	200.8	209.1
AWI	13.0	14.3	20.2
SDI	11.4	13.5	10.3
WDI	32.2	34.9	32.7
GC	6	6	6
HAMI	195.1	155.7	152.1
OAI	77.4	D	76.9
HASC	45	49	52
LLI	5.4	4.7	6.8
CLI	69.2	44.4	40.7
TOLI	16.3	16.8	14.4
DLI	70.0	56.1	34.2
SpLI	—	—	34.2
SpWI	—	—	5.6
SpRI	—	—	55.6
SpN	—	—	10
FLI	40.7	32.8	36.5
FFLI	44.0	51.3	78.1
FOI	91.7	97.9	95.7
FOLI	48.0	58.8	71.9
OcDI*	14.6	6.1	8.0

Table 2. Counts and indices for female *Octopus polyzenia* Gray, 1849.
(S = submature; M = mature; D = damaged; — = not recorded; * = OcDI measured as diameter of iridescent ring).

Museum Reg. No.	WAM 363-88	AM C48267	AM C164168	AM C164168	NTM P1451	AM C164168	NMV F60112
ML	13.9	24.9	25.8	32.5	32.8	33.3	37.7
StM	S	M	S	S	M	M	M
TL	59	93	90	119	121	126	133
MWI	74.1	71.1	69.4	72.9	57.6	77.5	61.5
HWI	63.3	53.0	49.2	48.3	43.0	46.5	41.1
HMWI	85.4	74.5	70.9	66.3	74.7	60.0	66.8
AMI: 1	230.2	188.8	186.0	206.2	210.4	216.2	183.0
2	251.8	224.9	220.9	224.6	207.3	228.2	209.5
3	309.4	236.9	236.4	258.5	247.0	270.3	212.2
4	302.2	261.0	232.6	261.5	247.0	261.3	246.7
AWI	25.9	17.7	17.1	18.2	18.6	17.1	19.9
SDI	12.9	9.2	9.3	8.9	9.1	8.4	7.7
WDI	39.1	29.2	32.8	27.1	30.9	27.8	26.9
GC	6	6	6	6	7	7	7
ELI		19.7			22.9	12.6	—
EWI		6.8			9.1	3.9	—
EN		100s			226	100s	100s
FLI	48.9	34.1	41.5	40.0	38.7	46.8	36.1
FFLI	76.5	71.8	61.7	70.8	63.8	62.2	54.4
FOI	100.0	94.0	91.4	97.0	93.8	90.2	99.0
FOLI	60.3	58.8	65.4	51.5	63.8	59.0	73.5
OcDI*	12.9	9.2	9.7	9.5	8.5	9.0	9.5

dorsal and dorsolateral webs. Sculpturing present on ventral surface of body, but absent from ventral arm crown. Longitudinal raised skin ridges visible on dorsal body (fig. 3a), largest 4 forming diamond arrangement. Additional shorter raised ridges on dorsal and lateral mantle. 1 large and 2 small branching papilla above each eye.

Sexual dimorphism not marked in the few specimens available. Mature males can possess 1–3 enlarged suckers on all arms at level of seventh sucker pair. Two other trends are visible in the limited material: i) mature males appear to have longer arms than females (AMI♂ mean *220.6*; ♀ mean *261.7*); yet, ii) females appear to have higher sucker counts than males (SC♀ mean *115*; ♂ mean *93*). When converted to a ratio of sucker count/arm length, the trend is clearer (SC/AL♀ 130.0-*154.4*-193.3, n = 6♀♀, ♂ 175.5, 207.7, 274.2). Additional material is required to confirm this trend.

Distribution. Octopus polyzenia is recorded from shallow, tropical waters across northern Australia (fig. 15b), from Bowen, Queensland (20°01′S, 148°15′E) west to Rosemary I., Dampier Archipelago, Western Australia (20°29′S, 116°35′E).

Life history. This taxon appears restricted to shallow, coastal waters on open substrata of sand or mud. Most specimens were collected by trawl or dredge between 1 and 20 m. The large eggs and well developed arms in very small juveniles from the type locality (31mm: 7.4-8.8 mm ML, NTM P1393) indicate hatchlings adopt a benthic habit.

Two specimens were accompanied by eggs laid in bivalve shells.

Commercial exploitation. There is no known exploitation of this species although it is likely to occur in low numbers in prawn trawl by-catch, particularly in the Gulf of Carpentaria.

Remarks. Brazier (1892) placed *O. polyzenia* in the synonymy of *O. granulatus* Lamarck, 1798, a species with no known type material or type locality. Other authors placed *O. polyzenia* in the synonymy of *O. rugosus* (Bosc, 1792) described from West Africa (Ortmann, 1891;

Robson, 1929; Flecker and Cotton, 1955), a species also lacking type material. The type locality of *O. rugosus*, and the absence of reference to ocelli in both *O. granulatus* and *O. rugosus* justify removing *O. polyzenia* from the synonymies of these species. The status of these two nominal taxa requires review.

Octopus exannulatus sp. nov.

Figs 1e, 7–10, 15c

Octopus membranaceus (non Quoy and Gaimard, 1832). — Lu and Phillips, 1985: 33.

Material examined. 137 preserved specimens examined in Australian museum collections and the National Museum of Natural History, Washington (USNM). The material listed was used to generate the description.

Holotype: Qld: 1♂: 46.7 mm ML, NMV F60143, Moreton Bay, 3 mi (5 km) N of E corner of Mud I., (about 27°23′S, about 153°15′E), W. Stephenson, 9 Dec 1966.

Paratypes: Qld: 1♂: 39.8 mm ML, QMB Mo29473, off Cairns, about 15 km SE of Fitzroy I., (about 17°00′S, about 146°05′E), 30 m, C. Jones, 25 Apr 1982 (Seibenhausen net); 1♂: 41.5 mm ML, USNM 817673, Moreton Bay, 3 mi N of E corner of Mud I., (about 27°23′S, about 153°15′E), W. Stephenson, 9 Dec 1966; 1♀: 41.8 mm ML, NMV F60105, Gulf of Carpentaria, 130 km W of Prince of Wales I., 10°56′S, 140°55′E, 44 m, C.C. Lu, 10 Sep 1982 (trawl, 1900–2000 hr); 1♀: 48.0 mm ML, QMB Mo29329, Moreton Bay, Peel I., Horseshoe Bay, (about 27°23′S, about 153°15′E, J.M. Raven, 9 Oct 1975; 1♀: 53.3 mm ML, NMV F60107, Gulf of Carpentaria, 50 km W of Port Musgrave, 11°57.5′S, 141°22′E, 38 m, C.C. Lu, 7 Sept 1982 (prawn trawl, 2052–2137 hr).

Other material: Qld: 1♂: 17.7 mm ML, QMB Mo29469, Moreton Bay, Middle Banks, (about 27°23′S, about 153°15′E), W. Stephenson, Mar, 1974; 2♂, 3♀: 27.5–41.5 mm ML, NMV F60104, Moreton Bay, (about 27°23′S, about 153°15′E), M. Potter, 22 Jul 1981; 1♂: 38.9 mm ML, QMB Mo29468, E of Cairns, 17°03.0′S, 146°07.8′E, 30.6 m, Queensland Fisheries Service, FRV "Southern Ocean", 28 Jan 1981 (single rigged try nets with tickler chains); 1♂: 39.3 mm ML, NMV F60106, Gulf of Carpentaria, 175 km W of Thursday I., 10°27′S, 140°45′E, 47 m, C.C. Lu, 13 Sep 1982 (trawl, 1900–2000 hr); 2♂: 41.3, 41.7 mm ML, NMV F60103, Moreton Bay, (about 27°23′S, about 153°15′E), Jan or Feb 1982.

WA: 1♀: 24.4 mm ML, WAM 352-88, Dampier Archipelago, 5–6 mi off "Brazont I.", 43 m, B.R. Wilson, FV "Daveno", 5 Jun 1960, (honolulu dredge on sand); 2♀: 23.6, 31.1 mm ML, NMV F60109, North West Shelf, 19°55.5′S, 117°55.5′E, 42 m, CSIRO, 22 Apr 1983 (beam trawl, 0845hrs); 1♀: 44.5 mm ML, NMV F60108, 50 km off Wickham, 20°15′S, 117°12′E, 40 m, CSIRO, 2 Jun 1990 (trawl, 1718 hr); 1♂: 45.4 mm ML, WAM 276-88, Shark Bay, 15 mi W of Carnarvon, (about 24°53′S, 113°40′E), L. Marsh and M. Sinclair, 3–4 Jul 1975 (trawl).

Diagnosis. Small to moderate sized species with simple black ocellus lacking an iridescent ring. 4 dark broad longitudinal stripes present on dorsal body extending on to arm crown. Dark leading edges present along length of dorsal edges of all arms. 7–8 gill lamellae per demibranch. Approximately 150 suckers per arm in females (SC♀ 136–*154*–188, n = 8), slightly fewer in males (SC♂ 123–*137*–162, n = 8); approximately 70 suckers on hectocotylized arm. Terminal organ large and recurved (TOLI about 40). Spermatophores very long, up to 1.5 times mantle length and produced in low numbers (SpN <10). Eggs moderately small, ovarian eggs to 3.9 mm [ELI(ov) to 7.3] and produced in large numbers (>5000).

Description. The following description based on 9 mature males, and 6 submature and 4 mature females. Counts and indices in Tables 3 and 4, with data from an immature male (17.1 mm ML, QMB Mo29469).

Small to medium-sized robust species (figs 1e, 7a, 10a): ML to at least 50 mm for both sexes, TL to at least 200 mm; weight to at least 75 g. Mantle round to ovoid (MWI 56.2–*67.4*–79.3), mantle walls thick and muscular. Stylets not found. Pallial aperture of moderate width, approximately half mantle width. Funnel muscular and broad based (FLI 31.8–*38.0*–45.0) with free portion usually greater than half funnel length (FFLI 40.4–*57.5*–78.6). Funnel organ W-shaped with broad limbs (fig. 7b). Outer limbs slightly shorter than median limb (FOI 79.4–*89.6*–97.2). Funnel organ large, approximately two-thirds of funnel length (FOLI 53.3–*67.0*–85.9).

Head of moderate width (HWI 41.7–*50.1*–60.7), narrower than mantle except in smallest specimen (HMWI 53.3–*74.9*–91.7). Neck distinct, slightly narrower than head. Eyes large and slightly pronounced.

Arms of moderate length, approximately 2–3 times ML (AMI 214.5–*245.2*–285.4), robust (AWI 13.3–*16.8*–20.1), roughly circular in cross section and tapering rapidly to fine tips in distal third. Dorsal arms shortest, lateral and ventral arms longer and more robust (AF generally 4.3.2.1 or 3.4.2.1). Suckers of moderate size, slightly elevated with distinct radial cushions, rim scalloped and often incurved. Mature males possess 2–4 considerably enlarged suckers at level of third sucker pair on arms 2 and 3 (SDI♂ 10.2–*14.3*–18.8; ♀ 7.1–*8.4*–9.5). Arm 3 or 4 possesses most suckers, approximately 150 per arm

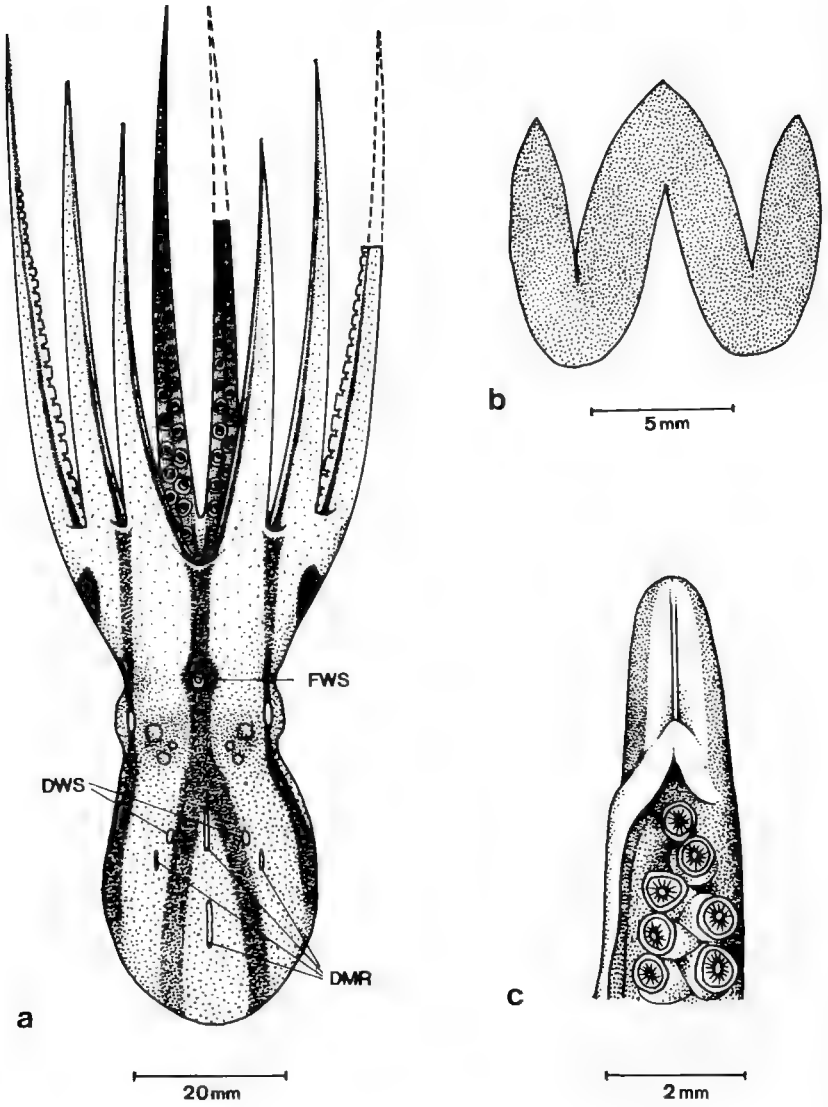


Figure 7. *Octopus exannulatus* sp. nov. a, dorsal view of 41.5 mm ML female (NMV F60104): DMR = dorsal mantle ridges; DWS = dorsal white spots; FWS = frontal white spot. b, funnel organ of 41.7 mm ML male (NMV F60103). c, copulatory organ of same specimen.

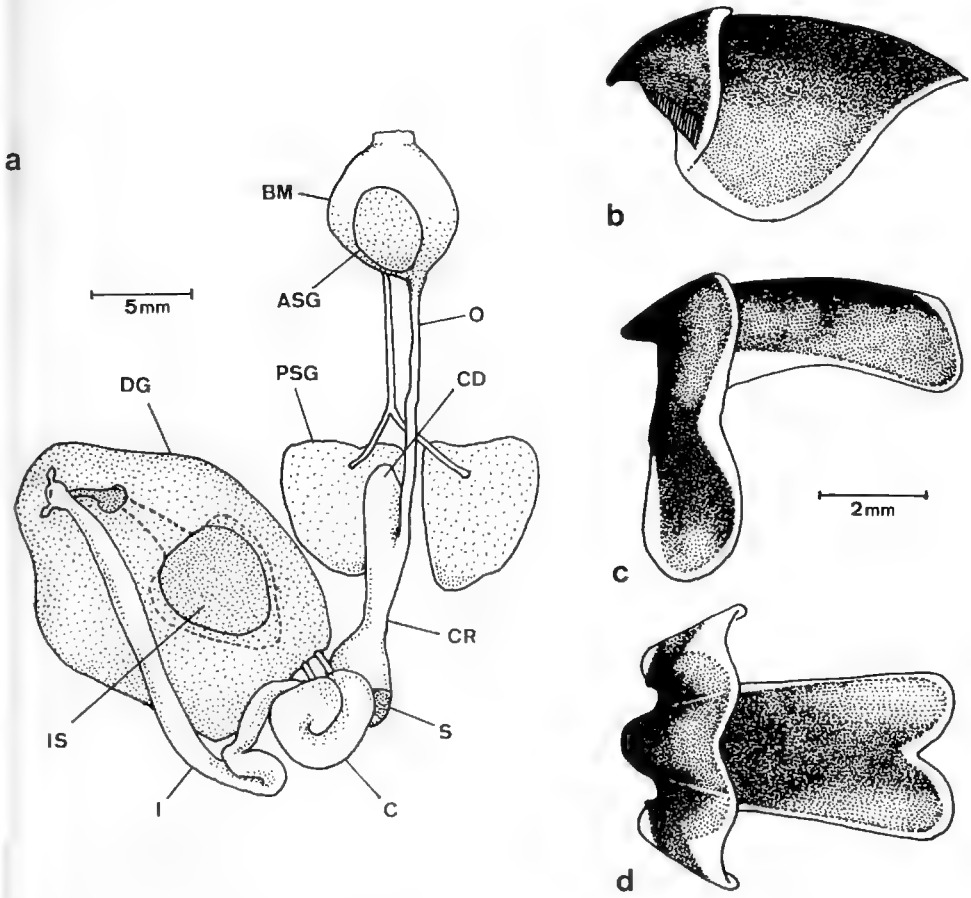


Figure 8. *Octopus exannulatus* sp. nov. a, digestive tract of 37.2 mm ML male (NMV F60104): hatched line indicates extent of ink sac embedded within digestive gland (for key to symbols see fig. 4). b, upper beak, lateral view of 34.9 mm ML female (NMV F60104). c, lower beak, lateral view of same specimen. d, lower beak, ventral view of same specimen.

in females (SC♀ 136–*154*–188, n = 8♀♀), slightly (not significantly) fewer in males (SC♂ 123–*137*–162, n = 7♂♂). Webs moderate to deep (WDI 24.3–*29.8*–37.1), deepest laterally, dorsal web distinctly shorter (WF typically D.C=E.B.A or D=C.E.B.A). Web margins well developed on ventral edges of arms, extending along approximately 80% of arm length.

Third right arm in males hectocotylized and slightly shorter than opposite arm (OAI: 74.6–*83.0*–97.6; HAMI: 158.6–*187.5*–218.5). Spermatophore groove well developed and wide with fine transverse ridges. Spermatophore guide deep with elevated square papillae. Mature copulatory organ small (fig. 7c: LLI 3.5–*4.3*–5.8), ligula roughly conical with blunt tip; groove

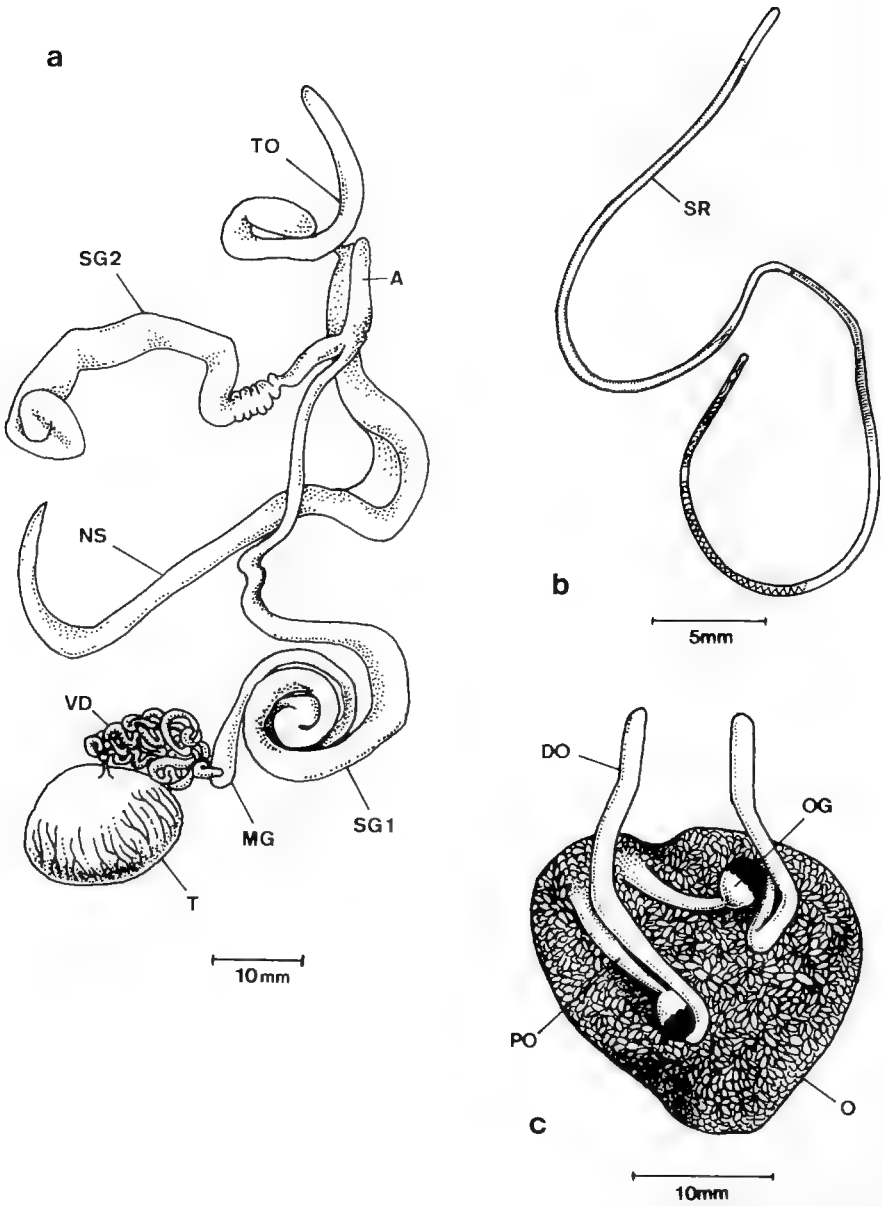


Figure 9. *Octopus exannulatus* sp. nov. a, male reproductive tract of 37.2 mm ML specimen (NMV F60104): for key to symbols see fig. 5.; A = appendix. b, spermatophore of 39.8 mm ML specimen (QMB Mo29473): SR = sperm reservoir. c, ovary of 44.5 mm ML specimen (NMV F60108): DO = distal oviduct; O = ovary; OG = oviducal gland; PO = proximal oviduct.

wide and shallow with a raised longitudinal midrib. Calamus medium size, slightly raised (CLI 19.4–*26.2*–34.2). Approximately 70 suckers on hectocotylized arm (HASC: 62–*69*–77).

Gills with 7–8 lamellae on both inner and outer demibranchs, plus a terminal lamella.

Digestive tract illustrated in figure 8a. Anterior salivary glands large, approximately 60% of buccal mass length. Posterior salivary glands well developed, slightly larger than buccal mass. Crop diverticulum distinct but not greatly developed. Stomach bipartite. Caecum coiled in single whorl. Muscular intestine reflexed approximately one-third of intestine length from proximal end. Ink sac well developed, embedded in ventral surface of digestive gland below iridescent tissue layer. Anal flaps present.

Upper beak (fig. 8b) with moderate hood and slightly hooked rostrum, concave on cutting edge. Ventral edge of hood with regular vertical ridges. Lower beak (figs 8c–d) with blunt rostrum, narrow hood, widely spread wings and slightly flared lateral walls. Ventral view of posterior margin moderately concave. Radula with seven teeth and two marginal plates in each transverse row (figs 10e–f). Rhachidian tooth with 1–2 lateral cusps, typically 1, on either side of a short robust medial cone. Lateral cusps are in symmetrical seriation, migrating from lateral to medial position over 2–3 rows. First lateral teeth unicuspidate with cusp towards lateral edge; second lateral teeth unicuspidate and long with curved base; lateral marginal teeth long, straight and robust; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 9a. Terminal organ in mature males very long, thin and recurved (TOLI: measured from tip to apex of curve: 34.1-*41.3*-48.1) with robust diverticulum (DLI 27.3-*34.4*-38.1), genital aperture subterminal. Vas deferens relatively robust and short. Mucilaginous gland enlarged at point of attachment to vas deferens. Spermatophoric gland I elongate and narrow with large recurved coil approximately 80% along length. Spermatophoric gland II long and narrow with reflexed tip. Appendix present at junctions of spermatophoric glands and Needham's sac. Needham's sac greatly elongated and narrow curved to follow curve of spermatophoric glands. Spermatophores (fig. 9b) very long (SpLI 136.8, 152.3, 162.4) and fine (SpWI 0.8–1.1), produced in low numbers (<10 in Needham Sacs of dissected males). Oral cap simple bearing cap thread. Sperm reservoir one third to one half spermatophore length (SpRI 37.4, 46.5, 46.9), retracted from tip of oral end in all preserved material examined. Sperm cord very fine and irregularly packed within the sperm reservoir, not forming regular whorls in material examined. Cement body not distinct in material examined.

Mature ovary oval shaped (fig. 9c). Oviducts robust and of moderate length. Oviducal glands large with approximately 15 radiating (braiding) chambers. Eggs small, ovarian eggs to 3.9 mm long [ELI(ovarian) to 7.3], moderately wide [EWI(ovarian) to 1.9] and produced in large numbers (at least 5000 ovarian eggs estimated from 1 specimen). 4–5 follicular folds on ovarian eggs.

Live specimens not witnessed. Preserved specimens exhibit 4 broad dark brown to black longitudinal stripes on dorsal body, over cream to red-brown base colour (fig. 7a). Inner pair of stripes extend along length of body joining at midpoint above eyes, continuing as single medial stripe to margin of dorsal web. Lateral body stripes commence from midway along lateral mantle, pass through the eye and extend on arm crown to margin of dorsolateral web. Thin dark brown to black lines extend along bases of suckers on dorsal faces of all arms. Plain dark brown to black ocellus present on each side of arm crown between bases of arms 2 and 3 (figs 10e-f; OcDI of black spot 14.8-*20.6*-28.8). Ring of iridescent tissue absent.

Several small circular pink spots are visible over base colour, 1 pair on dorsal body approximately one-third along body from level of eyes (fig. 7a). Circular frontal white spot on dorsal arm crown present just below eyes, in centre of medial dark stripe. Pigmentation reduced on ventral body and arm crown surfaces, but well developed on oral surface of dorsal web.

Body, arms and arm crown covered in small oval to round papillae, extending to arm faces and oral surface of dorsal and dorsolateral webs. Sculpturing present on ventral surface of body, but papillae almost twice diameter of those on dorsal surfaces. Sculpturing absent from ventral arm crown. 4 longitudinal raised skin ridges visible on dorsal body, in diamond arrangement (fig. 7a). Single large branching papilla above and slightly behind each eye, surrounded by additional smaller papillae (fig. 10a). Raised papilla present in centre of frontal white spot on dorsal arm crown.

Photographs of a live juvenile (15.1 mm ML, AM C168950) were provided by I. Loch (AM). Resting colour was orange-brown with longitudinal bars partially suppressed and dorsal mantle white spots clearly visible. Alarm color-

Table 3. Counts and indices for male *Octopus exannulatus* sp. nov.
(I = immature; S = submature; M = mature; D = damaged; ID = indistinct; — = not recorded; * = OcDI measured as diameter of black spot).

Museum Reg. No.	QMB Mo29469	NMV F60104	NMV F60104 (Paratype)	QMB Mo29468	NMV F60106 (Paratype)	QMB Mo29473 (Paratype)	USNM 817673 (Paratype)	NMV F60103	WAM 276-88	NMV F60143 (Holotype)
ML	17.7	27.5	37.2	38.9	39.3	39.8	41.5	41.7	45.4	46.7
StM	I	M	M	M	M	M	M	M	M	M
TL	60	90	121	146	140	144	149	142	173	146
MWI	60.5	70.2	65.1	77.6	63.6	59.8	68.4	63.5	62.3	63.2
HWI	65.0	60.7	59.7	48.6	44.5	46.5	51.8	47.7	50.2	48.2
HMWI	107.4	86.5	91.7	62.6	70.0	77.8	75.7	75.1	80.6	76.3
AMI: 1	180.8	167.3	174.7	223.7	239.2	228.6	180.7	175.1	209.3	D
2	169.5	210.9	198.9	239.1	241.7	241.2	204.8	194.2	233.5	D
3	214.7	214.5	198.9	233.9	208.7	D	226.5	247.0	251.1	D
H	169.5	160.0	158.6	218.5	203.6	193.5	197.6	187.1	193.8	192.7
4	220.3	229.1	215.1	259.6	231.6	213.6	238.6	225.4	270.9	D
AWI	15.8	16.4	18.3	20.1	17.3	15.3	15.9	15.6	16.5	15.6
SDI	7.3	10.2	13.2	17.5	11.7	12.1	18.8	15.6	10.6	18.8
WDI	34.4	30.2	27.5	34.7	28.4	32.3	30.3	26.2	27.6	32.6R
GC	7	8	8	7	8	8	8	8	7	7
HAMI	169.5	160.0	158.6	218.5	203.6	193.5	197.6	187.1	193.8	192.7
OAI	78.9	74.6	79.7	93.4	97.6	D	87.2	75.7	77.2	D
HASC	68	68	66	68	74	76	70	62	77	68
LLI	1.3	5.5	5.8	3.5	3.9	3.6	3.7	4.1	4.1	4.2
CLI	ID	25.0	35.3	23.3	19.4	21.4	30.0	28.1	19.4	34.2
TOLI	ID	38.2	37.4	48.1	34.1	46.5	42.2	46.0	36.8	42.8
DLI	ID	38.1	27.3	31.6	33.6	36.8	32.0	28.6	49.1	32.5
SpLI		—	162.4	—	—	—	—	152.3	136.8	—
SpWI		—	0.8	—	—	—	—	0.8	1.1	—
SpRI		—	46.5	—	—	—	—	46.9	37.4	—
SpN		—	—	—	—	—	—	9	—	—
FLI	39.5	33.5	34.1	38.3	37.4	37.7	39.5	41.2	35.9	38.1
FFLI	42.7	61.8	54.3	53.0	57.2	55.4	57.3	49.5	78.6	40.4
FOI	93.5	92.4	89.2	87.5	90.5	91.3	86.1	85.7	ID	94.6
FOLI	65.7	85.9	73.2	64.4	64.6	53.3	65.6	61.0	ID	62.4
OcDI*	20.9	20.0	14.8	21.9	27.5	17.6	21.7	22.1	19.8	18.2

Table 4. Counts and indices for female *Octopus exannulatus* sp. nov.
(S = submature; M = mature; D = damaged; ID = indistinct; — = not recorded; * = OcDI measured as diameter of black spot).

Museum Reg. No.	NMV F60109	WAM 352-88	NMV F60109	NMV F60104	NMV F60104	NMV F60104	NMV F60105 (Paratype)	NMV F60108	QMB Mo29329 (Paratype)	NMV F60107 (Paratype)
ML	23.6	24.4	31.1	34.9	34.9	41.5	41.8	44.5	48.0	53.3
StM	S	S	S	S	S	M	M	M	S	M
TL	96	87D	111	110	114	129	155	181	161	205
MWI	72.0	79.3	76.5	66.8	65.0	68.2	56.2	72.8	60.8	79.2
HWI	57.6	57.9	48.2	56.4	55.6	54.5	43.1	41.8	41.7	42.2
HMWI	80.0	73.0	63.0	84.4	85.1	79.9	76.7	57.4	68.6	53.3
AMI: 1	254.2	231.4	199.4	163.3	166.2	178.3	196.2	206.7	175.0	245.8
2	275.4	D	228.3	197.7	194.8	200.0	220.1	262.9	191.7	251.4
3	296.6	D	241.2	209.2	206.3	209.6	256.0	262.9	208.3	264.5
4	279.7	D	247.6	214.9	217.8	214.5	251.2	285.4	220.8	285.2
AWI	17.4	19.4	16.7	18.1	16.9	18.6	16.5	16.6	13.3	15.2
SDI	8.5	9.5	7.1	8.9	8.3	9.4	7.9	8.8	8.3	7.5
WDI	37.1	—	32.5	32.0	26.3	29.2	25.2	32.3	28.3	24.3
GC	7	7	7	7	8	8	7	8	8	8
ELI						5.5	—	4.9		7.3
EWI						1.7	—	1.6		1.9
EN						>5000	>>1000	>>1000		>>1000
FLI	42.4	45.0	36.0	37.8	34.4	31.8	39.0	38.2	39.6	39.6
FFLI	59.9	D	68.9	69.0	57.6	47.8	57.7	61.8	63.1	53.0
FOI	ID	79.4	ID	87.9	94.7	97.2	93.1	85.1	87.6	90.3
FOLI	ID	62.4	ID	75.0	78.3	80.3	62.6	59.4	67.9	58.8
OcDI*	28.8	28.5	18.0	18.3	16.9	15.9	22.7	19.3	19.6	21.2

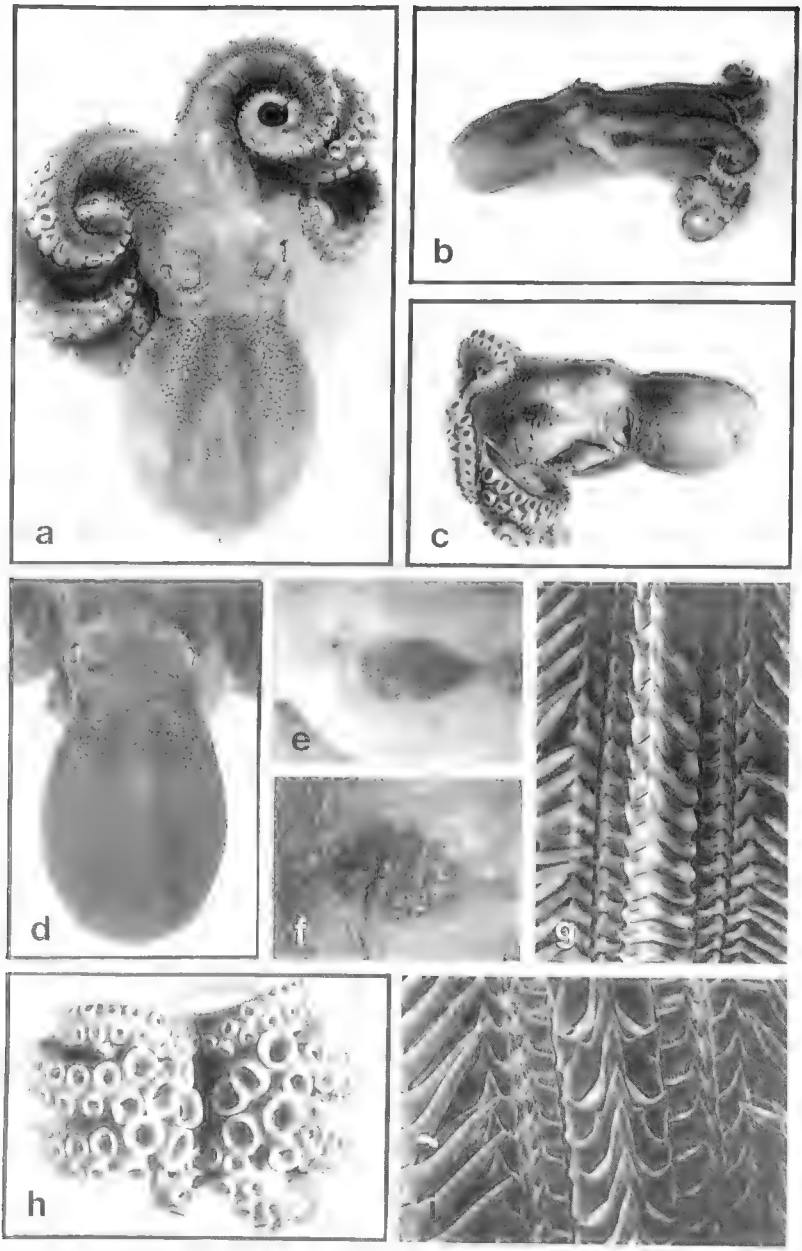

a
b
c
d
e
f
g
h
i

Figure 10. Photographs of preserved specimens of *Octopus exannulatus* sp. nov. a, dorsal view of 41.5 mm ML male (USNM 817673). b, lateral view of 41.8 mm ML female paratype (NMV F60105). c, lateral view of 46.7 mm ML male paratype (USNM 817673). d, dorsal view of 41.8 mm ML female (NMV F60105). e, ocellus of 41.8 mm ML female paratype (NMV F60105). f, ocellus of 46.7 mm ML male paratype (USNM 817673). g, i, radula of 34.9 mm ML female (NMV F60104). h, enlarged suckers of 41.5 mm ML mature male (USNM 817673).

←

ation consisted of red-brown longitudinal bars over white base colour.

Sexual dimorphism is not marked in this species. Both sexes attain approximately equal maximum size. Mature males possess 2–4 enlarged suckers on arms 2 and 3 at level of third sucker pair (SDI♂ mean *14.3*; ♀ mean *8.4*). Females appear to possess more suckers than males (SC♀ 136-*154*-188; ♂ mean 123-*137*-162, difference not significant at P = 0.05 level).

Distribution. *Octopus exannulatus* is recorded from tropical Australian waters (fig. 15c), from Shark Bay, Western Australia (24°49′S, 113°33′E) to Gulf of Carpentaria, Torres Strait and south to Moreton Bay, southern Queensland (27°15′S, 153°15′E).

Life history. It has been collected from exposed intertidal mudflats to 84 m deep, on muddy, sandy and shelly sand substrata. This species appears to inhabit open bottom substrata and seagrass beds.

Prawn trawler operators fishing within Great Barrier Reef waters report catches of this distinctive species in trawls on sand or muddy substrates.

Commercial exploitation. *Octopus exannulatus* occurs in fairly low numbers in the by-catch of Moreton Bay, Great Barrier Reef and Gulf of Carpentaria trawl fisheries, particularly prawn fisheries. This species is often retained for use as bait. No information is available on scale of catch.

Etymology. From the Latin, *ex* (without) and *annulus* (ring), referring to the simple black ocellus which lacks an iridescent ring.

Remarks. Lu and Phillips (1985) reported this species under the name *O. membranaceus* Quoy and Gaimard, 1832. Despite the poor condition of the type of *O. membranaceus*, it clearly possesses an iridescent ring within its ocellus, easily distinguishing it from *O. exannulatus*.

Octopus mototi sp. nov.

Figs 1f, 11–14, 15d

Octopus membranaceus. — Loch, 1987: 8, textfigs. (non Quoy and Gaimard, 1832)

Material examined. 2 live *O. mototi* were encountered on offshore islands at the southern end of the Great Barrier Reef. 8 preserved specimens were examined in Australian museum collections, the National Museum of Natural History, Washington and the Muséum National d'Histoire Naturelle, Paris.

Holotype: Qld: 1♂: 66.2 mm ML, NMV F60101, Capricorn Bunker Group, Heron I., 23°50′S, 152°25′E, 31 m, M. Norman and R. Fenwick, 30 Aug 1990 (raised in pot at 0945 hr, on sandy bottom in channel on N side of island).

Paratypes: Qld: 1♀: 58.6 mm ML, NMV F60102, Capricorn Bunker Group, One Tree I., 23°30′S, 152°05′E, 1 m, M. Norman and R. Fenwick, 7 Sep 1990 (deep in lair, 1415 hr, in dead coral within lagoon, on sand, flushed with $CuSO_4$); 1♀: 73.3 mm ML, AM C154277, Coral Sea, Wreck Reef, NE of West Islet, 22°12′S, 155°10′E, 12 m, P. Cook and B. Bately, 30 Oct 1983 (in lair during day, under dead staghorn clump on sand, caught by hand on SCUBA); 1♀: 76.7 mm ML, QMB Mo29325, Swains Reef, 21°46.9′S, 152°50.0′E, 54 m, C. Jones, Swains Reef Survey Station 12, 27 July 1987 (trawled with Seibenhausen net).

Austral Is: 1♂: 70.5 mm ML, USNM 817681, Rapa I., about 27°36′S, 144°20′W, G. Paulay, 6 Jun 1980 (captured by local islanders).

Other material: Qld: 1♂: about 55 mm ML (in two pieces, arm crown with intact arms and bulk of body; head missing), QMB Mo29466, no locality data; 1♂: 60.6 mm ML, NMV F60142, off Caloundra, 26°40′S, 153°16′E, 22 fm (40.3 m), Adam Butcher, QDPI, "San Antone", 22 Jul 1991 (prawn trawl, just before dusk).

New Caledonia: 1♀: 100.0 mm ML, MNHN 2010, off Noumea, (about 22°30′S, 166°40′E), Alan Gerbault, no date; 1♀: 100.5 mm ML, MNHN 2011, North Lagoon, (about 22°30′S, 166°40′E), 1990.

Diagnosis. Moderate sized species with black oval ocellus containing iridescent blue ring. Circular cluster of dark spots above each eye forms "flower" pattern. Alarm colour pattern of white base colour and 6 dark maroon longitudinal stripes on dorsal body and arm crown. 9–11 gill lamellae per demibranch, typically 11. Approximately 160 suckers per arm, roughly equal in number in both sexes in the material available (SC♂ 149, 176; ♀ 143–*159*–172, n = 4♀♀), approximately 100 suckers on hectocotylized arm. Terminal organ short and robust (TOLI about 20). Spermatophores of moderate length (SpLI about 70) and produced in low numbers

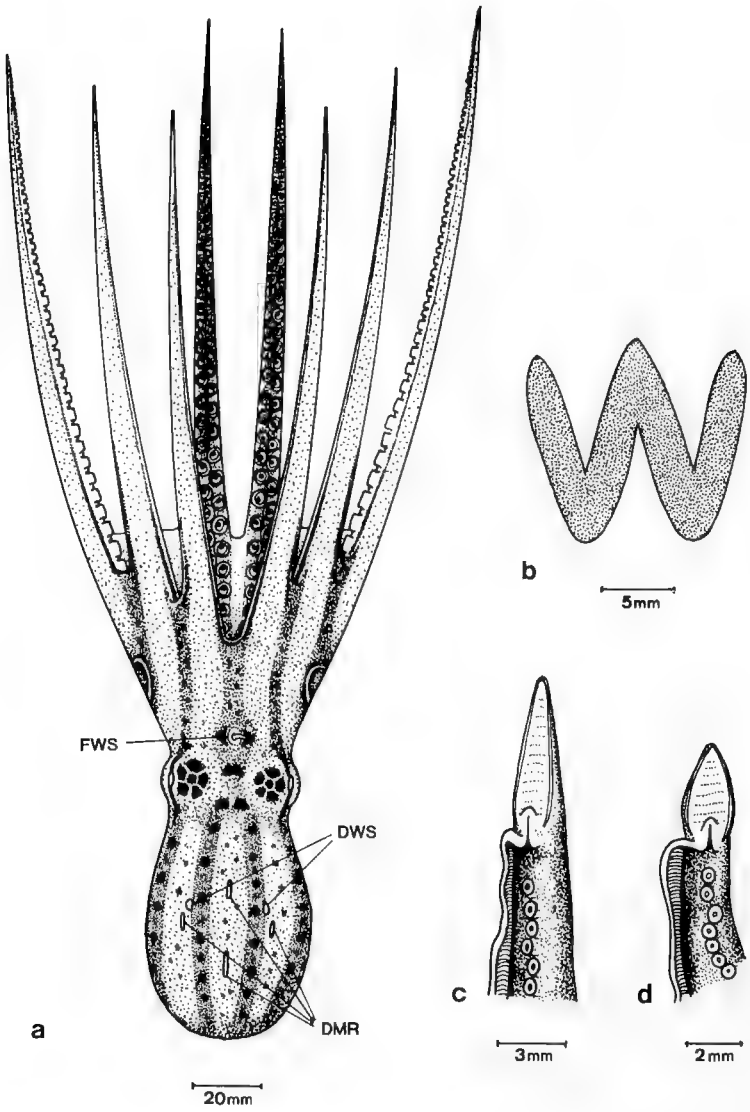


Figure 11. *Octopus mototi* sp. nov. a, dorsal view of 73.3 mm ML female paratype (AM C154277): DMR = dorsal mantle ridges; DWS = dorsal white spots; FWS = frontal white spot. b, funnel organ of 58.6 mm ML female paratype (NMV F60102). c, copulatory organ of 66.2 mm ML holotype (NMV F60101). d, copulatory organ of 70.5 mm ML paratype (USNM 817681).

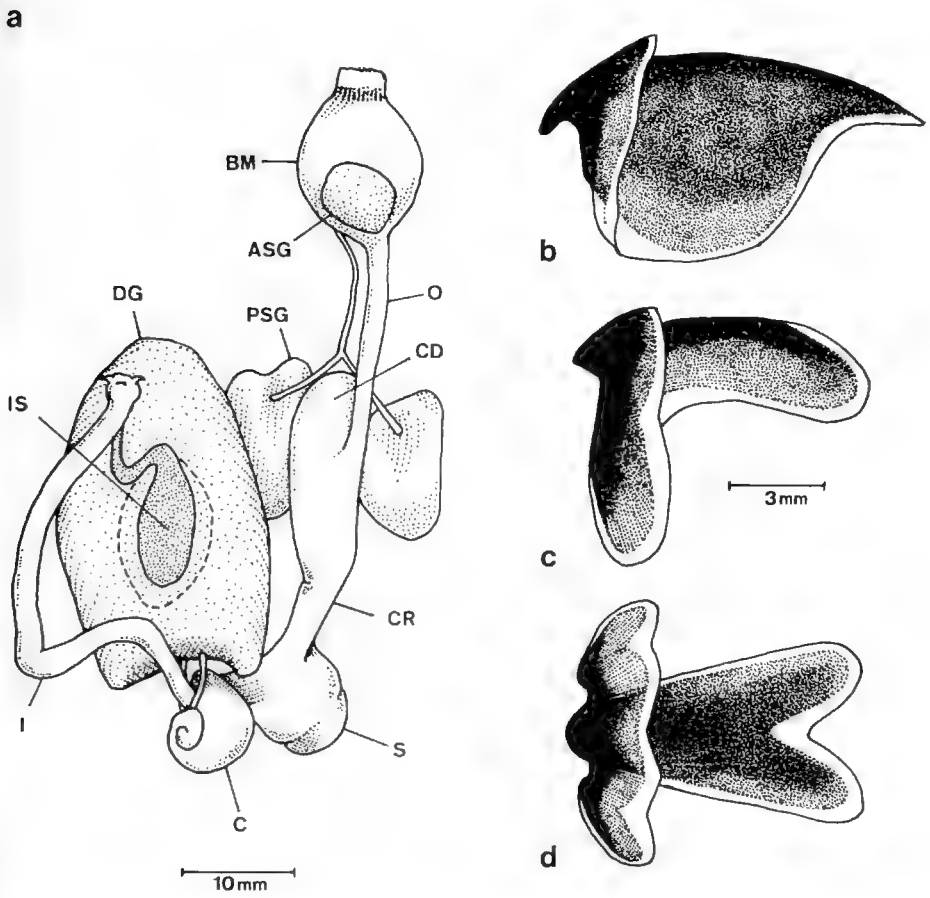


Figure 12. *Octopus mototi* sp. nov. a, digestive tract of 58.6 mm ML female paratype (NMV F60102): hatched line indicates volume of ink sac embedded within digestive gland (for key to symbols see fig. 4). b, upper beak, lateral view of same specimen. c, lower beak, lateral view of same specimen. d, lower beak, ventral view of same specimen.

numbers (SpN <10). Eggs moderately small, ovarian eggs to 6 mm, spawned egg capsules to 3.2 mm [ELI(ov) to 7.8, ELI(sp) to 4.2], produced in large numbers (EN >10 000).

Description. Based on 3 mature males, and 1 submature/mature and 4 mature females. Counts and indices in Table 5 and 6.

Moderate sized, robust species (figs 1f, 11a): ML to at least 70 mm for males and 100 mm for females, TL to at least 320 mm; weight to at least 300 g. Mantle ovoid (MWI 52.8–*64.3*–70.4), mantle walls thick and muscular. Stylets not found. Pallial aperture of moderate length, approximately half mantle width. Funnel muscular and broad based (FLI 34.5–*37.1*–40.0) with free portion usually greater than half funnel length (FFLI 43.5–*64.0*–82.6). Funnel organ W-shaped with broad limbs (fig. 11b). Outer limbs slightly shorter than median limb (FOI

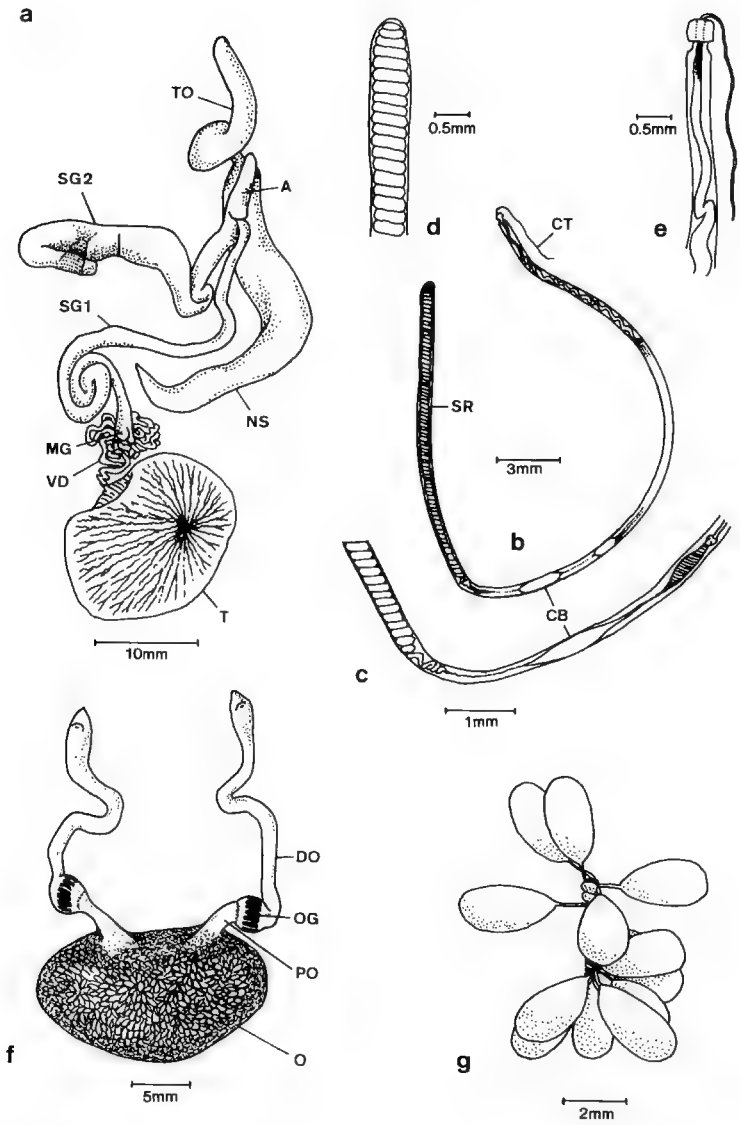


Figure 13. *Octopus mototi* sp. nov. a, male reproductive tract of 66.2 mm ML holotype (NMV F60101): for key to symbols see fig. 5.; A = appendix. b–e, spermatophore from same specimen. b, entire spermatophores: CB = cement body; CT = cap thread; SR = sperm reservoir. c, midsection indicating position of cement body. d, oral cap. e, aboral cap bearing cap thread. f, ovary of 58.6 mm ML female paratype (NMV F60102): DO = distal oviducts; O = ovary; OG = oviducal gland; PO = proximal oviduct. g, section of festoon of spawned eggs from 76.7 mm ML female paratype (QMB Mo29325).

Table 5. Counts and indices for male *Octopus mototi* sp. nov.
(M = mature; D = damaged; — = not recorded; ID = indistinct; # = specimen frozen, hectocotylized arm distorted at tip; * = OcDI measured as diameter of iridescent ring).

Museum Reg. No.	NMV F60101 (Holotype)	USNM 817681 (Paratype)	NMV F60142	QMB Mo29466
ML	66.2	70.5	60.6	~55
StM	M	M	M	M
TL	255	260	D	~192
MWI	70.4	65.7	52.8	D
HWI	52.7	46.4	42.7	D
HMWI	74.8	70.6	80.9	D
AMI: 1	226.6	228.4	D	~201.8
2	271.9	235.5	D	~232.7
3	268.9	249.6	D	D
H	250.8	217.0	236.0	~221.8
4	249.2	252.5	D	~258.2
AWI	18.6	14.9	13.4	~12.4
SDI	13.0	9.4	10.1	~6.9
WDI	25.6	29.8	D	D
GC	11	11	10	10
HAMI	250.8	217.0	236.0	~221.8
OAI	93.3	86.9	D	D
HASC	100	106	95	103
LLI	5.4	3.1	6.7#	~2.0
CLI	36.7	48.9	54.2#	D
TOLI	25.7	20.0	24.9	~15.5
DLI	37.1	30.5	46.4	49.4
SpLI	70.2	59.4	D	—
SpWI	1.3	1.2	D	—
SpRI	34.8	35.3	D	—
SpN	—	5	6	—
FLI	40.0	35.9	34.5	D
FFLI	82.3	43.5	49.3	D
FOI	ID	86.6	100	D
FOLI	ID	56.1	63.6	D
OcDI*	14.4	15.9	18.2	~15.6

85.5–*91.0*–100.0). Funnel organ large, approximately 60% of funnel length (FOLI 56.1–*61.1*–63.9).

Head of moderate width (HWI 46.4–*49.3*–56.6), always narrower than mantle (HMWI 70.6–*76.7*–81.1). Neck distinct, slightly narrower than head. Eyes large and slightly pronounced.

Arms of moderate length, 2.5–3 times ML, slightly longer in females of material examined (AMI♂ 252.5, about 258, 268.9; ♀ 261.7–*292.2*–314.0). Arms robust (AWI 10.5–*15.5*–24.6), square in cross section and tapering rapidly to fine tips in distal third. Dorsal arms shortest, lateral and ventral pairs longer and more robust (AF typically 4=3.2.1). Suckers of moderate size, slightly elevated with distinct radial cushions and scalloped rim. Suckers approximately equal in size for both sexes in limited specimens available (SDI♂ about 6.9, 9.4, 10.1, 13.0; ♀ 10.5–*11.3*–13.6). The holotype exhibits slight enlargement of several suckers at level of fifth to sixth sucker pair on arms 2 and 3. Arms 3 or 4 possess most suckers, approximately 160 per arm, roughly equal in number in both sexes in available material (SC♂ 149, 176; ♀ 143–*159*–172, n = 4). Webs moderate to deep (WDI 25.6–*30.4*–38.8), deepest laterally, dorsal web distinctly

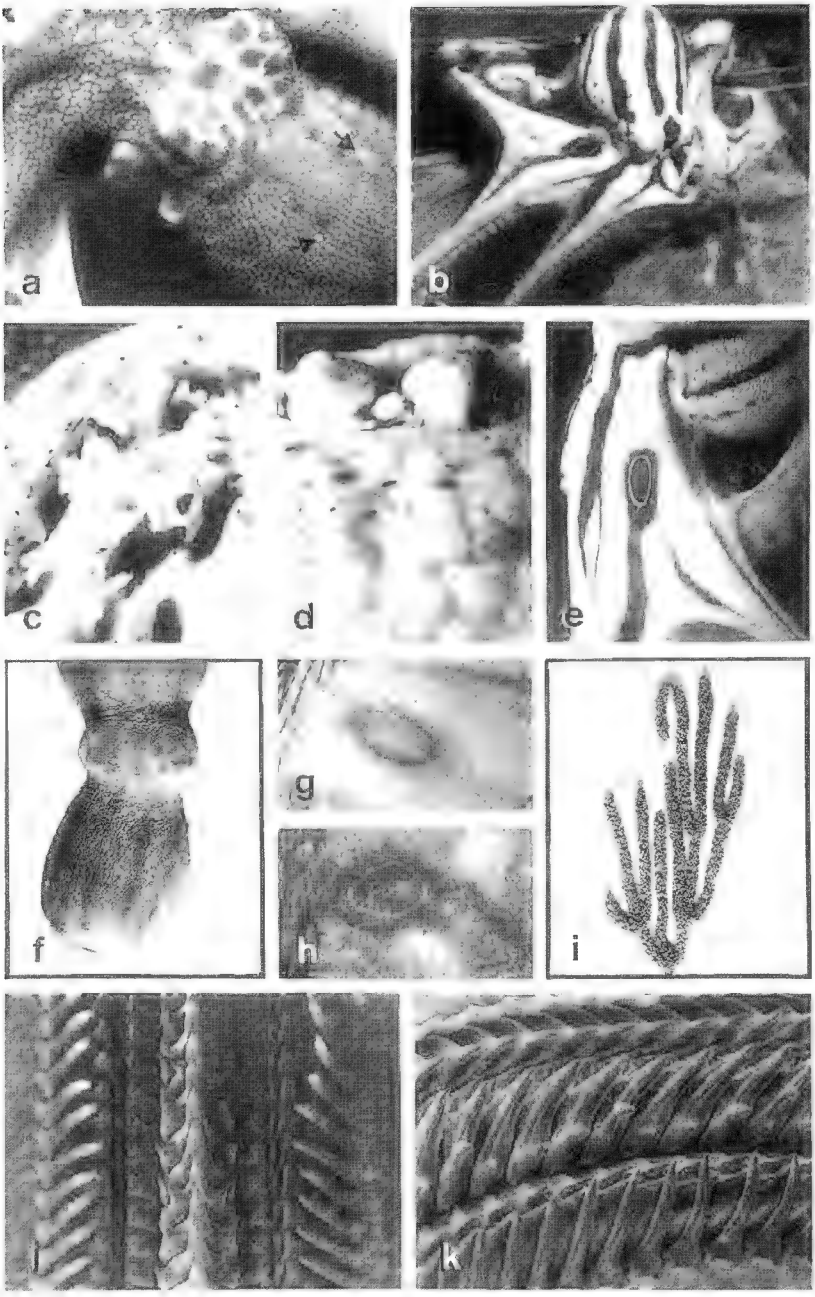

a
b
c
d
e
f
g
h
i
j
k

Figure 14. Photographs of *Octopus mototi* sp. nov. a–e, colour patterns of live animals: a, resting colouration of 66.2 mm ML male holotype (NMV F60101); arrows indicate dorsal white spots. b, alarm coloration of 58.6 mm ML female paratype (NMV F60102). c, wild animal in Coral Sea, emerging from conch shell displaying eye bar and "flower" pattern above each eye (Photo courtesy of Neville Coleman). d, posture of arms drawn back along body exposing suckers, beak and displaying frontal white spot and spotted oral surface of dorsal web (58.6 mm ML female paratype: NMV F60102). e, alarm colouration of same specimen. f, colour pattern in preserved 73.3 mm ML female paratype (AM C154277). g, preserved ocellus of same specimen. h, preserved ocellus of 76.7 mm ML female paratype (QMB Mo29325). i, festoon of spawned eggs from same specimen. j, k, radula of 58.6 mm ML female paratype (NMV F60102).

shorter (WF typically D.C=E.B.A). Web margins extend along approximately 60% of ventral edges of arms.

Third right arms in males hectocotylized and slightly shorter than opposite arm (OAI: 86.9, 93.3; HAMI: 217.0, about 222, 236.0, 250.8). Spermatophore groove well developed and wide with fine transverse ridges. Spermatophore guide distinct with cross ridges but no obvious papillae. Copulatory organ small (fig. 11c: LLI 3.1, 5.4 for 2 mature males, 6.7 in distorted frozen specimen, NMV F60142), ligula roughly conical; groove wide and shallow bordered laterally by fine skin ridges. Calamus medium size and slightly raised (CLI 36.7, 48.9). Copulatory organ on male from Rapa I. (USNM 817681) slightly shorter and broader (fig. 11d) than that of holotype, but still bears distinctive skin ridges bordering ligular groove. Approximately 100 suckers on hectocotylized arm (HASC: 95–*101*–106).

Gills with 9–11 lamellae, typically 11, on both inner and outer demibranches, plus a terminal lamella.

Table 6. Counts and indices for female *Octopus mototi* sp. nov. (S = submature; M = mature; D = damaged; — = not recorded; ID = indistinct; # = from ovarian eggs, capsule of spawned eggs much shorter; ## = counted from festoons of spawned eggs; * = OcDI measured as diameter of iridescent ring).

Museum Reg. No.	NMV F60102 (Paratype)	AMS C154271	QMB Mo29325 (Paratype)	MNHN 2010	MNHN 2011
ML	58.6	73.3	76.7	100.0	100.5
StM	M	S/M	M	S/M	M
TL	228	290	324	425	366
MWI	69.6	65.3	69.8	D	56.5
HWI	51.9	52.7	56.6	D	41.9
HMWI	74.6	80.7	81.1	D	74.1
AMI: 1	240.6	252.4	D	271.0	210.0
2	261.1	274.2	286.8	294.0	D
3	D	307.0	305.1	293.0	261.7
4	273.0	286.5	D	314.0	243.8
AWI	16.2	10.5	24.6	16.1	12.8
SDI	11.6	10.5	13.6	10.5	10.5
WDI	26.9	32.0	29.5	38.8	D
GC	11	10	9	10	10
ELI	—	—	7.8#	—	—
EWI	—	—	1.7#	—	—
EN	—	—	~10 700##	—	>>1000
FLI	39.2	38.5	34.6	36.7	D
FFLI	73.5	58.2	82.6	58.3	D
FOI	91.8	85.5	ID	ID	ID
FOLI	63.9	61.0	ID	ID	ID
OcDI*	13.7	19.1	16.6	14.3	14.0

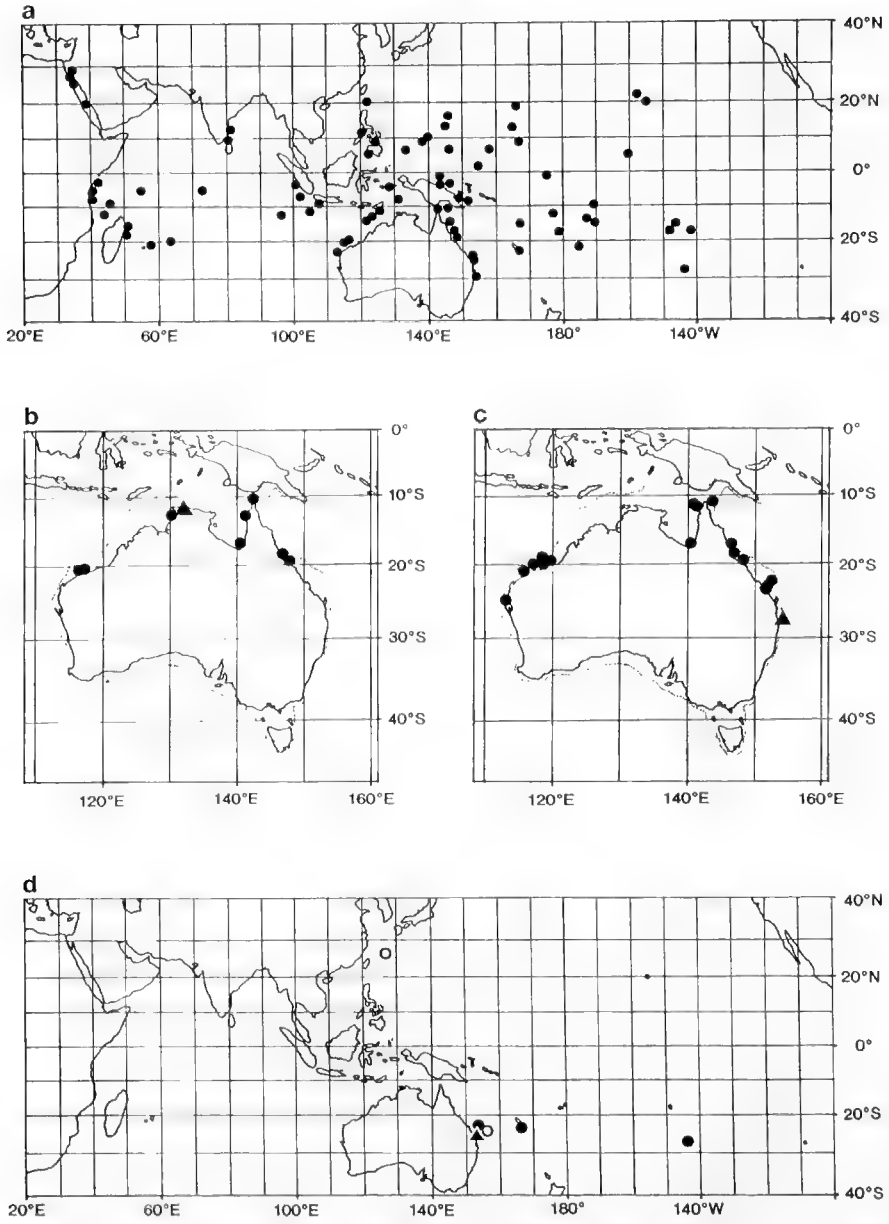


Figure 15. Distributions of Great Barrier Reef ocellate octopuses. a, *Octopus cyanea* Gray, 1849: ● = material examined. b, *Octopus polyzenia* Gray, 1849: ▲ = type locality; ● = other material examined. c, *Octopus exannulatus* sp. nov.: ▲ = type locality; ● = other material examined. d, *Octopus mototi* sp. nov.: ▲ = type locality; ● = other material examined; ○ = photographic records.

Digestive tract illustrated in figure 12a. Anterior salivary glands of moderate size, approximately half buccal mass length. Posterior salivary glands well developed, approximately equal in length with buccal mass. Crop diverticulum distinct. Stomach bipartite. Caecum coiled in single whorl. Intestine poorly preserved in dissected specimen, reflexed at proximal third, rectum not distinct. Ink sac well developed, embedded in ventral surface of digestive gland. Anal flaps present and fine. Membrane on dorsal surface of visceral mass pigmented with large dark chromatophores, remnants of larval or founder chromatophores.

Upper beak (fig. 12b) with moderate hood and short hooked rostrum, concave on cutting edge. Lower beak (figs 12c–d) with blunt rostrum, narrow hood, widely spread wings and moderately flared lateral walls producing moderately concave posterior margin from ventral view. Radula with seven teeth and two marginal plates in each transverse row (figs 14j–k). Rhachidian tooth with 1–2 lateral cusps, typically 1, on either side of a robust medial cone. Lateral cusps are in symmetrical seriation, migrating from lateral to medial position over 4–6 rows. First lateral teeth unicuspidate with cusp towards lateral edge; second lateral teeth unicuspidate and long with curved base; lateral marginal teeth long, straight and robust; marginal plates oblong and plain.

Male reproductive tract illustrated in figure 13a. Terminal organ in mature males moderate to large and robust (TOLI about 15.5, 20.0, 24.9, 25.7), diverticulum moderate sized (DLI 30.5–40.9–49.4), genital aperture subterminal. Vas deferens thin and of moderate length. Mucilaginous gland enlarged at point of attachment to vas deferens. Spermatophoric gland I robust with large recurved coil approximately three-quarters along length. Spermatophoric gland II long and robust, tip reflexed. Appendix present at junction of spermatophoric glands and Needham's sac. Needham's sac moderately short, tapering to fine point at posterior end. Spermatophores (fig. 13b–e) of medium length (SpLI 59.4, 70.2) and fine (SpWI 1.2, 1.3), produced in low numbers (<10 in Needham's sac of holotype; 4 in Rapa I. male, 6 in NMV F60142). Oral cap simple, showing slight restriction below tip, bearing long cap thread. Sperm reservoir approximately one third of spermatophore length (SpRI 34.8, 35.3). Sperm cord coiled in approximately 75 coils (holotype: 76; Rapa I. male: 75).

Mature ovary oval shaped (fig. 13d). Distal oviducts robust and reflexed midway along length, extending to level of anus and flattened distally. Proximal oviducts originate laterally on ovary, not obviously from common origin in specimen examined. Oviducal glands large with 16–20 radiating (braiding) chambers. Eggs (fig. 13g) medium sized, ovarian eggs to 6 mm total length [ELI(ovarian) to 7.8], spawned eggs with smaller capsule to 3.2 mm [ELI(spawned) to 4.2]. Eggs moderately wide [EWI(ovarian) 1.7; EWI(spawned) 2.0] and produced in large numbers (about 10,700 eggs accompanied 76.7 mm ML female, QMB Mo29325). Eggs laid in long branching festoons (fig. 14i). Approximately 6 follicular folds on immature ovarian eggs.

Colour in life variable. Ocellus on each side of arm crown between bases of second and third arms, each containing a large iridescent blue ring (figs 14e, g–h; OcDI for iridescent ring 13.7–15.9–19.1). Iridescent ring masked in some colour patterns, exaggerated by dark background in alarm colouration (fig. 14e).

Resting animals exhibit orange-cream base colour with darker brown spots in six longitudinal series along dorsal body (fig. 14a). Cluster of 5 large spots around a central spot above each eye, form "flower" pattern (fig. 11a, 14a). "Flower" pattern often visible in specimens within, or partially emerged from, lairs (fig. 14c). Circular frontal white spot visible on dorsal arm crown just below eyes, containing thin erectile papilla (fig. 11a). Small pair of dorsal white spots midway along dorsal mantle visible over darker resting base colour (fig. 11a, 14a).

Alarm display of distinctive striped colour pattern over white base (fig. 14b, e). 6 solid dark maroon longitudinal stripes form on dorsal body extending on to arm crown and down ventral edges of arms. Median pair of dorsal stripes extend to near eyes, dorsolateral pair continue through eyes down ventral edge of arm 1, and lateral pair cease at pallial aperture. Additional medial stripe commences between eyes, divides each side of frontal white spot and rejoins to continue to margin of dorsal web, fine stripe continuing down dorsal edge of arm 1. Dark oval spot can be expressed under iridescent ring of ocelli, extending distally to form wide stripe down ventral edge of arm 2 and fine stripe down dorsal edge of arm 3 (fig. 14e). "Flower" pattern of spots above eyes sometimes pronounced in alarm displays, other times suppressed. Alarmed individuals often retreat into crevices or corners and raise arms over body to display frontal white

spot, suckers and beak. In this posture, dark spots are clearly visible against white base on oral face of dorsal and dorsolateral webs (fig. 14d). This characteristic pattern is clearly visible on individuals deep within lairs.

Skin sculptured in patch and groove system consisting of oval to round patches (fig. 14a), extending on to oral surface of dorsal and dorsolateral webs and arm faces. Raised erectile papilla in centre of frontal white spot distinct in most colour patterns. 4 longitudinal skin ridges in diamond arrangement on dorsal mantle (fig. 11a). Single small supraocular papilla above and slightly behind each eye in centre of "flower" pattern of spots.

Skin sculpturing and some colour patterns are visible in preserved specimens (figs 14f–h).

Sexual dimorphism is not marked in the few specimens examined. Females attained largest size in available material, 100 mm ML versus 70 mm ML in males. Females appear to have slightly longer arms than males (AMI♂ 252.5, about 258.2, 268.9; ♀ 261.7–*292.2*–314.0).

Distribution. Octopus mototi is reported from eastern Australian waters: Capricorn-Bunker Group, southern end of the Great Barrier Reef; Swains Reefs and Wreck Reef, Coral Sea. Neville Coleman (pers. comm.) provided an additional record of this species from Saumarez Reef, Coral Sea (21°45′S, 153°40′E), photographing an individual at 10 m on sand occupying a large gastropod shell (fig. 14c). This species is also recorded from the South Pacific (fig. 15d): New Caledonia (22°33′S, 166°40′E) and Rapa I. (27°36′S, 144°20′W). Dr Okutani (Tokyo University of Fisheries) has a 77 mm ML female specimen of this species from Okinawa, south of Japan (26°30′N, 128°00′E). Photographs of this specimen kindly provided by Dr Okutani show the characteristic "flower" pattern above the eyes, longitudinal rows of spots on dorsal mantle and display of black spots on oral surface of dorsal web.

Octopus mototi has been collected from shallow subtidal depths (<1 m) down to 54 m, on sandy substrates near coral or coral rubble in clear water.

Life history. Octopus mototi appears to favour sandy substrata, often associated with coral heads or rubble. Deep lairs are excavated under coral heads or coral rubble. From limited observations, this species appears to have crepuscular activity patterns.

Examination of stomach and intestine contents found a high proportion of crustacean exoskeleton fragments. The lair of one specimen collected from One Tree I. lagoon was surrounded by discarded gastropod shells. It is likely that *O. mototi* preys on hermit crabs, discarding empty gastropod shells outside the mouths of lairs. Loch (1987) documented the shells surrounding the lair of the Swains Reef specimen (AM C154277) which included 15 gastropod species, predominantly *Fusinus undatus* and *Strombus* spp. Loch noted many shells exhibited two drill holes, one produced by naticid gastropods, the other by an octopus. Loch suggested that this was consistent with this octopus species drilling these shells to prey on secondary occupants, namely hermit crabs.

Eggs are laid in large numbers in festoons (fig. 14i). It is not known whether eggs are attached to the substrate or carried in the web of the female. This species lays small eggs indicating hatchlings are planktonic.

Octopus mototi may prove to be venomous. This species has a prominent warning colouration and is known locally on Rapa I. as the "poison octopus" (G. Paulay, pers. comm.). The two specimens encountered in the field showed a willingness to bite objects such as aquarium nets, a behaviour not observed in other Great Barrier Reef octopuses.

Etymology. On Rapa I., South Pacific (27°36′S, 144°20′W) the local name attributed to this octopus is "*fe'e mototi*", "*fe'e*" meaning octopus and "*mototi*" meaning poison, referring to the reported poisonous nature of this distinctive species (G. Paulay, USNM, pers. comm.) (noun in apposition).

Discussion

Systematics. Ocellate octopuses are found in two separate regions of the world: i) the Indo-West Pacific centred in the tropical waters of southeast Asia and tropical Australia; and ii) the Americas, centred on the east and west coasts of central America.

Fifteen species and three subspecies of ocellate species have been described from Indo-West Pacific waters (Table 7). Of these many are inadequately described, lack type material or are synonymous with others. The list can be reduced to eight apparently valid taxa from these waters (including the two new species described here): "iidako" (*O. areolatus* d'Orbigny, 1839 / *O. fangsiao* d'Orbigny, 1839 / *O. ocellatus* Gray, 1849); *O. polyzenia* Gray, 1849; *O. cyanea* Gray, 1849; *O. ovuhum* Sasaki, 1917; *O. robsoni* Adam,

Table 7. List of nominal species of ocellate octopuses described from Indo-West Pacific waters.

Species		Type locality	Remarks
Octopus membranaceus Quoy and Gaimard, 1832		Papua New Guinea	Nomen dubium: type damaged
Octopus pulcher Brock, 1887		Amboina	Nomen dubium: type lost
"iidako": Probable synonyms			
	Octopus areolatus d'Orbigny, 1839	Japan	Valid
	Octopus fangsiao d'Orbigny, 1839	Japan	—
	Octopus ocellatus Gray, 1849	China	—
	Octopus brocki Ortmann, 1888	Japan	—
	Polypus fangsiao typicus Sasaki, 1929	Japan	—
	Polypus fangsiao etchuanus Sasaki, 1929	Japan	—
Octopus polyzenia Gray, 1849		Australia, Nth Territory	Valid
Octopus cyanea Gray, 1849		"Coasts of New Holland" (= Australia)	Valid
Synonyms	*Octopus marmoratus* Hoyle, 1885	Hawaii	—
	Octopus horsti Joubin, 1898	Red Sea	—
	Octopus herdmani Hoyle, 1904	Ceylon	—
	Octopus cyanea gracilis Robson, 1929	Madras	—
	Callistoctopus magnocellatus Taki, 1964	Japan	—
Octopus ovulum Sasaki, 1917		"Japan" (questionable)	Status unclear
Octopus robsoni Adam, 1941		Red Sea	Valid
Octopus varunae Oommen, 1971		West coast of India	Possible synonym of *O. robsoni*

1941, *O. varunae* Oommen, 1971; *O. exannulatus* sp. nov.; and *O. mototi* sp. nov.

The presence of an iridescent ring (ie. metallic blue, gold, silver or green colours produced by iridophores) within the ocellus of some species has been noted by many workers (e.g., Brock, 1887; Robson, 1929; Sasaki, 1929; Adam, 1959, Okutani et al., 1987). Voss (1963) suggested that the presence of this ring depended on the nature and duration of preservation. Adam (1973) disputed this and proposed that this character was constant within and between species. Adam's proposal holds true for the material examined in this study. There were no inconsistencies in the several hundred specimens examined. The iridescent ring found in the ocellus of species such as *O. polyzenia* and *O. mototi* was always visible even in poorly preserved material. Similarly, more than 200 specimens of *O. cyanea* and *O. exannulatus* were examined and none possessed an iridescent ring.

The absence of the iridescent ring in *O. cyanea* and *O. exannulatus* is sufficient to distinguish these taxa from those listed above, as all of the remaining species possess this iridescent ring. Several taxa require additional comment.

(1) "tidako". There appears to be a single common ocellate species in shallow coastal waters from Japan to Hong Kong, which in Japan goes under the common name "tidako". It is characterised by a large green to gold iridescent ring within each ocellus, a dumbbell-shaped head patch, 7–8 gill lamellae and large eggs (7–10 mm). Gleadall and Naggs (1991) proposed that this species should be assigned the name *O. fang-siao* d'Orbigny, 1839, a name d'Orbigny derived from earlier Japanese descriptions of this distinctive species (Terajima, 1713; Katsuma, 1762). No type material was designated. *Octopus areolatus* also was described by d'Orbigny in the same work (1839) and has page priority. The original description is inadequate, having been based on a description provided in a letter from De Haan but the two syntypes of *O. areolatus* collected by De Haan from Japan are in the Royal Museum in Leiden (collection numbers 490 and 2438). These types are clearly specimens of "tidako". The latter name is therefore the valid senior synonym but the status of these two names requires further clarification. In this discussion, this taxon is referred to by the vernacular name, "tidako". The following nominal taxa are considered synonymous:

Octopus areolatus d'Orbigny, 1839; *Octopus fang-siao* d'Orbigny, 1839; *Octopus ocellatus* Gray, 1849; *Octopus brockt* Ottmann, 1888; *Polypus fang-siao typicus* Sasaki, 1929; *Polypus fang-siao etchuanus* Sasaki, 1929.

Octopus polyzenia is similar to "tidako" in sharing large eggs, iridescent ring within ocellus and moderately low gill count (6–7 vs 7–8). However it differs in possessing widely spaced transverse bars on all arms and lacks the gold/brown dumbbell-shaped patch on the head between the eyes, characteristic of "tidako". These colour patterns are consistent on all specimens examined of both *O. polyzenia* and "tidako" (over 30 of the latter species have been examined in NMV, AM, QMB, NMNH, CAS, BMNH and MNHN collections). *Octopus polyzenia* is also distinct from this taxon in having a lower hectocotylized arm sucker count (about 50 vs 90+) and in possessing enlarged suckers on all arms at the level of the seventh row (vs. enlarged suckers on arms 2 and 3 only at the third row in "tidako"). "Tidako" occurs in northern hemisphere warm temperate waters and consequently its distribution is unlikely to extend to Australia.

(2) *Octopus membranaceus* Quoy and Gaimard, 1832 has been reported widely throughout the Indo-West Pacific region. The type is in the Muséum d'Histoire Naturelle, Paris (MNHN 4-7-922) and was examined in November 1991. It is a small immature female (22.0 mm ML) in poor condition. Despite this condition, an iridescent ring within each ocellus is still clearly visible. The inadequate original description and the badly damaged type do not allow further clarification of this species. The name is here proposed as *nomen dubium*. All previous reports of this species and, where possible, the original specimens need to be re-examined. The name has been used in Japan and Hong Kong, applied to "tidako" (Tryon, 1879; Cox, 1882; Voss and Williamson, 1971; Lam and Chiu, 1983; Roper, Sweeney and Nauen, 1984; Khromov, 1990). Voss (1963) reported this species from the Philippines based on a single female specimen (20.0 mm ML, USNM 575405). This specimen was examined in the USNM in October 1990. It lacks the iridescent ring in the ocellus and appears to be an undescribed species.

There are two reports of *O. membranaceus* from Australian waters. Odhner (1917: 12, 70) reported this species from the north west coast of Western Australia on the basis of three small ocellated specimens, the largest with a mantle length of 17 mm. No description was provided and the specimens have not been traced to date. At least four species of ocellated octopus occur in these waters and Odhner's specimens may

belong to one or more of these taxa. It is unlikely that this record will be resolved unless the original material surfaces. Lu and Phillips (1985: 33) reported *O. membranaceus* from Moreton Bay and the Gulf of Carpentaria. These reports refer to specimens of the new species, *O. exannulatus*.

(3) *Octopus ovulum* Sasaki, 1917 was described as a small-egg species based on material purchased from Tokyo Fish Market. No subsequent records of a small-egg ocellate species in Japanese waters have emerged and it is possible that Sasaki's material originated from outside Japanese waters. The type material may have been collected from tropical Indo-West Pacific waters and transported to Japan for sale. Sasaki's description of this species shows some similarities with an undescribed species from Thai waters. Further study will be required to resolve the status of this taxon.

(4) *Octopus robsoni* Adam, 1941 was described from the Red Sea. The type material is in the Muséum National d'Histoire Naturelle, Paris and was examined in November 1991. This moderately small species is aligned with the small Indo-Malayan ocellates. It lays moderately small eggs (ovarian eggs about 5 mm long), has 10 gill lamellae per demibranch and a fine purple iridescent ring in the ocellus. Mature males possess a very long fine copulatory organ (LLI 9.0) and two to three enlarged suckers at the level of the third sucker pair on arms 2 and 3, with slightly enlarged suckers on arm 4. This combination of characters distinguishes this species from the ocellate species of the Great Barrier Reef.

(5) *Octopus varunae* Oommen, 1971 was described from four males and two females collected from 125–135 m off the west coast of India. This species is known only from the original description. It possesses an ocellus with an iridescent ring, lays small eggs (ovarian eggs about 2 mm long), has 10 gill lamellae per demibranch and a long narrow copulatory organ. No material of this species has been examined by the author. *Octopus varunae* shows many similarities with *O. robsoni* and further study is required to delineate these forms. It is distinct, however, from Great Barrier Reef ocellate octopuses.

Table 8 summarises the character states of the Great Barrier Reef ocellate octopuses and compares them with known characters for other Indo-West Pacific ocellates. Data for the latter group of species is taken from original descriptions ("iidako" from Sasaki, 1929 as *O. fangsiao*

Table 8. Comparison of Great Barrier Reef and other ocellate octopuses of the Indo-West Pacific region.

	Great Barrier Reef species				Indo-West Pacific species			
	O. cyanea	*O. polyzenia*	*O. exannulatus*	*O. mayon*	"iidako"	*O. ovulum*	*O. robsoni*	*O. varunae*
Size (ML)	to 160 mm	to 38 mm	to 50 mm	to 100 mm	>50 mm	to 40 mm	to 60 mm	to 60 mm
Arm length (AMI)	400–580	200–310	215–290	250–310	220–360	180–280	240–280	160–230
Iridescent ring	no	yes	no	yes	yes	yes	yes	yes
Gill count (GC)	9–10–11	6–7	7–8	9–11	7–8	7–8	8–10	10
Sucker count (SC)	>400	103–135	120–190	140–180	—	—	110–150	—
Hect. Arm SC (HASC)	160–199–229	45–50–52	62–70–77	95–101–106	90–140	120–140	61	—
Egg size (mm)	2.7 ov.	3.5 sp	3.9 ov.	3.2 sp	10 ov.	3 ov.	5.2 ov.	2 ov.
Egg Length Index (ELI)	1.7 ov.	22.9 sp	7.3 ov.	4.2 sp	~20 ov.	6.7 ov.	8.8 ov.	3.3 ov.
Spermatophore length (SpLI)	32–50	~35	135–160	60–70	60–70	>100	~60	—

var. *typicus*) and supplemented with counts and measurements taken from the type of *O. robsoni* and specimens of "iidako" from NMNH and CAS.

Great Barrier Reef ocellate octopuses fall into two groups of potentially different origin. *Octopus polyzenia*, *O. exannulatus* and *O. mototi* show close affinities with all other Indo-Malayan ocellates in sharing: small body size, short arms (AMI about 200–280), body patterns that often include four to six wide longitudinal stripes on the dorsal mantle and arm crown, moderately low sucker counts (SC about 100–200, HASC about 50–100), and medium sized copulatory organs (LLI about 5+).

Octopus cyanea, despite possessing ocelli, is clearly of different origin from the above ocellate species. It shares greater affinities with *O. vulgaris* Lamarck, 1798 and several ocellate species of the Americas [*O. bimaculatus* Verrill, 1883, *O. bimaculoides* Pickford and McConnaughy, 1949; *O. maya* Voss and Solis Ramirez, 1966 and *O. oculifer* Hoyle, 1904 (senior synonym of *O. roosevelti* Stuart, 1941, *fide* Hochberg, in prep.)]. *Octopus cyanea* shares the following characters with many of these species: larger body size, long arms (AMI about 300–500), absence of four to six wide longitudinal stripes in body patterns, high sucker counts (SC >400, HASC about 200), and tiny copulatory organ (LLI <2).

Biogeography. Distributions of the four ocellate octopuses in the Great Barrier Reef region fall into three patterns.

Octopus cyanea is a widely-distributed species found in clear tropical waters of the Pacific and Indian oceans, from Hawaii in the east to the African coast in the west (fig. 15a). This distribution spans the Indo-West Pacific region (Briggs, 1974). Such a distribution is seen in a wide range of tropical marine organisms and is characteristic of fauna or flora with a lengthy planktonic phase in their life cycles (Ekman, 1967; Briggs, 1974). *Octopus cyanea* lays very small eggs (2 mm long, ELI 1.7) and the young enter the plankton on hatching (Van Heukelem, 1976). The duration of this planktonic phase is not known but must be sufficiently long to enable hatchlings to traverse the extensive areas of open ocean between island groups.

The distribution of *O. mototi* is also wide ranging (fig. 15d), apparently limited to the tropical Pacific Ocean. In the east, specimens have been collected from the South Pacific, the east coast of Australia and south of Japan. This species may prove to have a distribution restricted to the rim of the Pacific Plate as reported for certain fish species in Springer (1982). The eggs of *O. mototi* are moderately small (ovarian eggs to 5 mm, ELI 7.8) indicating that hatchlings are planktonic.

Octopus exannulatus and *O. polyzenia* exhibit distributions restricted to the tropical coastal waters of northern Australia, referred to as the "Northern Tropical Zone" or "Northern Australian Region" by Wilson and Allen (1987). Many other tropical Australian marine biota exhibit this distribution, including fishes (Wilson and Allen, 1987), echinoderms (Rowe, 1985) and another octopus species, *Ameloctopus litoralis* Norman, 1992 (Norman, 1992a). Both *O. polyzenia* and *O. exannulatus* occur in shallow and muddy coastal waters, on sand and/or mud substrates. These habitats are continuous from southern Queensland to Shark Bay, Western Australia. *Octopus exannulatus* lays moderately small eggs (ovarian eggs to 4 mm long, ELI 7.3) suggesting that hatchlings spend at least some time in the plankton. This species could potentially disperse across its range in the plankton, and may prove to also occur along the southern Papua New Guinea coastline where similar habitats exist. *Octopus polyzenia* lays relatively large eggs (spawned egg capsules to 8 mm long, ELI >20) indicating hatchlings spend little time in the plankton. In this species, dispersal must be limited to the distribution of shallow mud and sand substrata in tropical Australian waters.

Acknowledgments

This research forms part of a PhD research program into octopods of the Great Barrier Reef and northern Australia, being carried out in association with the Museum of Victoria and the University of Melbourne. Sincere thanks to: C.C. Lu, F.G. Hochberg, G.F. Watson and T. Stranks for assistance with the manuscript and project; R. Fenwick, M. Turner, S. Troy, C. Davies, J. Martin, J. Swartz, G. Greenwood and the Breidahl family for field assistance; G. Paulay (USNM) for information on Rapa I. material; M. Potter and M. Dunning, Queensland Department of Primary Industries for provision of material from Queensland waters; I. Loch, P. Colman, B. Rudman (AM), F. Naggs (BMNH), T. Gosliner (CAS), R. and G. Boucher-Rodoni (MNHN), L. Vail, D. White (NTM), J. Stanisic (QMB), C. Roper and M. Sweeney (NMNH) and S. Slack-Smith (WAM)

for assistance and access to collections; J. Hoey, Townsville Reef Wonderland Aquarium for access to aquarium facilities; D. Paul and C. Rowley for assistance with photographic plates; N. Coleman for access to his photographic index (AMPI).

This research was made possible through support grants from the Museum of Victoria, Victorian Institute of Marine Sciences, Australian Museum (Postgraduate and Keith Sutherland Awards), Great Barrier Reef Marine Park Authority, University of Melbourne M.A. Bartlett Travel Grant and Write-up Award, Joyce W. Vickery Research Fund (Linnean Society of NSW), Ethel Mary Read Fund (Royal Zoological Society of New South Wales), Potter Foundation, Hawaiian Malacological Society, Royal Society of Victoria and Western Society of Malacologists. Certain Museum of Victoria material referred to in this paper was collected with the assistance of the captain and crew of FV "Susan Wright" of K.F.V Fisheries, Townsville, through financial support by FIRTA to Dr C.C. Lu (NMV).

References

Adam, W., 1939. The Cephalopoda in the Indian Museum, Calcutta. *Records of the Indian Museum* 41: 61–110.

Adam, W., 1941. Notes sur les Céphalopodes. XVI. – Sur une nouvelle espèce de Céphalopode (*Octopus robsoni* sp. nov.) de la Mer Rouge. *Bulletin du Musée royal d'Histoire naturelle de Belgique* 17 (52): 1–5.

Adam, W., 1959. Les Céphalopodes de la Mer Rouge. *Résult scientifique de Mission de Robert Ph. Dollfus en Égypte 1927–1929* (3) 28: 125–193.

Adam, W., 1973. Cephalopoda from the Red Sea. Contributions to the knowledge of the Red Sea, No. 47. *Bulletin of the Sea Fisheries Research Station, Haifa* (60): 9–47.

Berry, S.S., 1912. On the cephalopods new to California with a note on another species. *Annual report of Laguna Marine Laboratory*: 83–87, textfigs 44–48.

Berry, S.S., 1912a. A catalogue of Japanese Cephalopoda. *Proceedings of the Academy of Natural Sciences of Philadelphia* 380–444, textfigs 1–4, pls V–IX.

Brazier, J., 1892. Catalogue of the marine shells of Australia and Tasmania. Part I. Cephalopoda. *Australian Museum Catalogue* 15: 1–19.

Briggs, J.C., 1974. *Marine Zoogeography*. McGraw-Hill: New York. 475 pp.

Brock, J., 1887. Indische Cephalopoden. *Zoologische Jahrb'chen* 2: 591–614, pl. 16, figs 1–4.

Cox, J.C., 1882. Australian Octopodidae. *Proceedings of the Linnean Society of New South Wales* 6: 773–789.

Ekman, S., 1967. *Zoogeography of the Sea*. Sidgwick and Jackson: London. 417 pp.

Flecker, H. and Cotton, B.C., 1955. Fatal bite from octopus. *Medical Journal of Australia* 27 Aug 1955: 329–332, 2 figs.

Gleadall, I.G. and Naggs, F.C., 1991. The Asian ocellate octopuses. II. The validity of *Octopus fangsiao* d'Orbigny. *Annals of Applied Information Sciences* 16 (2): 173–180, 2 figs.

Gray, J.E., 1849. *Catalogue of the Mollusca in the collection of the British Museum. I. Cephalopoda Antepedia*. London. 164 pp.

Hoyle, W.E., 1886. A catalogue of recent Cephalopoda. *Proceedings of the Royal Physical Society of Edinburgh* 9: 205–267.

Hoyle, W.E., 1907. The marine fauna of Zanzibar and East Africa, from collections made by Cyril Crossland in 1901–1902. The Cephalopoda. *Proceedings of the Zoological Society of London* 00: 450–461, pl. XX, textfigs. 128, 137.

Katsuma, R., 1762. *Oozukushii ("Just Fishes")*. Manuscript, National Diet Library, Tokyo (*fide* Gleadall and Naggs, 1991).

Khromov, D.N., 1990. Cephalopods of the Vietnamese waters: the fauna and distribution patterns. *ICES 1990/Shell, Paper* 12: 1–9, 1 fig.

Lam, V.W.W. and Chiu, S.T., 1983. Prey selection and feeding behaviour of *Octopus membranaceus* (Quoy and Gaimard, 1832). Pp. 661–681, 6 pls, 8 figs *in*: Morton, B. and Dudgeon, D. (eds), *Proceedings of the Second International Workshop on the Malacofauna of Hong Kong and Southern China*. Hong Kong University Press: Hong Kong.

Loch, I., 1987. An eight armed, blue ringed, fusinophilic. *Australian Shell News* 57: 8–9, 2 pls.

Lu, C.C. and Phillips, J.U., 1985. An annotated checklist of the Cephalopoda from Australian waters. *Occasional Papers from the Museum of Victoria* 2: 21–36, 1 fig.

Norman, M.D., 1991. *Octopus cyanea* Gray, 1849 (Mollusca: Cephalopoda) in Australian waters: description, distribution and taxonomy. *Bulletin of Marine Science* 49 (1–2): 20–38, 5 figs.

Norman, M.D., 1992a. *Ameloctopus litoralis*, gen. et sp. nov. (Cephalopoda: Octopodidae), a new shallow water octopus from tropical Australian waters. *Invertebrate Taxonomy* 6 (5): 567–582, 5 figs.

Norman, M.D., 1992b. Four new octopus species of the *Octopus macropus* group (Cephalopoda: Octopodidae) from the Great Barrier Reef, Australia. *Memoirs of the Museum of Victoria*, 53: 267–308.

Odhner, N.H.J., 1917. Results of Dr. E. Mjöberg's Swedish scientific expeditions to Australia, 1910–1913. Part XVII. Mollusca. *Kunliga Svenska Vetenskapsakademiens, Handlingar* (4th ser.) 52 (16): 1–115, 3 pls, 51 figs.

Okutani, T., Tagawa, M. and Horikawa, H., 1987. Cephalopods of continental shelf and slope around Japan. *Japan Fisheries Resource Conser-*

vation Association 194 pp, textfigs.

Oommen, V.P., 1971. *Octopus varunae*, a new species from the west coast of India. *Bulletin of the Department of Marine Biology and Oceanography, University of Cochin* 5: 69–76, 6 figs.

Ortmann, A., 1888. Japanische Cephalopoden. *Zoologische Jahrbücher Abtheilung für Systematik, Geographie und Biologie der Thiere* 3: 639–670, pls 20–25.

Ortmann, A., 1891. Cephalopoden von Ceylon. *Zoologische Jahrbücher, Abtheilung für Systematik, Ökologie und Geographie der Thiere* 5: 669–679, pls XLVI.

Pickford, G.E. and McConnaughey, B.H., 1949. The *Octopus bimaculatus* problem: a study in sibling species. *Bulletin of the Bingham Oceanographic Collection* 12: 1–66.

Rees, W.J., 1950. The Cephalopods of the Cocos-Keeling Islands collected by C.A. Gibson-Hill. *Bulletin of the Raffles Museum, Singapore* 22: 99–100.

Robson, G.C., 1929. *A monograph of the Recent Cephalopoda. I. Octopodinae.* British Museum (Natural History): London. 236 pp.

Roper, C.F.E. and Hochberg, F.G., 1987. Cephalopods of Lizard I., Great Barrier Reef, Australia. *Occasional Papers from the Museum of Victoria* 3: 15–20.

Roper, C.F.E. and Hochberg, F.G., 1988. Behaviour and systematics of cephalopods from Lizard Island, Australia based on colour and body patterns. *Malacologia* 29 (1): 153–193.

Roper, C.F.E. and Sweeney, M.J., 1983. Techniques for fixation, preservation, and curation of cephalopods. *Memoirs of the Museum of Victoria* 44: 29–47.

Roper, C.F.E., Sweeney, M.J. and Nauen, C.E., 1984. FAO Species Catalogue, Volume 3. Cephalopods of the World. *FAO Fisheries Synopses*, (125) 3: 196 pp, textfigs.

Roper, C.F.E. and Voss, G.L., 1983. Guidelines for taxonomic descriptions of cephalopod species. *Memoirs of the Museum of Victoria* 44: 49–63.

Rowe, F.W.E., 1985. Preliminary analysis of distribution patterns of Australia's non-endemic, tropical echinoderms. Pp. 91–98 *in:* Keegan, B.F. and O'Connor, B.D.S. (eds), *Proceedings of the 5th Echinoderm Conference, Galway, Ireland, 24–29 September, 1984.* Rotterdam: Balkema.

Sasaki, M., 1917. Notes on the Cephalopoda. *Annotationes Zoologicae Japonenses* 9 (3): 361–367.

Sasaki, M., 1929. A monograph of the dibranchiate cephalopods of the Japanese and adjacent waters. *Journal of the Faculty of Agriculture, Hokkaido Imperial University* 20 (supplement) 357 pp, 30 pls.

Smith, E.A., 1884. Mollusca. *Report on the zoological collections made in the Indo-Pacific Ocean during the voyage of the HMS "Alert" 1881–2* 00: 34–116, 1 pl.

Springer, V.G., 1982. Pacific Plate biogeography, with special reference to shorefishes. *Smithsonian Contributions to Zoology* 367: 1–182.

Terajima, Y., 1713. *Wakan Sansui Zue ("Japanese Illustrated Encyclopedia")*, 51: 17–18, Manuscript, National Diet Library, Tokyo (*fide* Gleadall and Naggs, 1991).

Tryon, G.W., 1879. Volume 1: Cephalopoda. *Manual of Conchology* 1: 1–316, pls 1–111.

Van Heukelem, W.F., 1976. Growth, bioenergetics and life span of *Octopus cyanea* and *Octopus maya*. PhD dissertation, University of Hawaii. 224 pp.

Van Heukelem, W.F., 1983. *Octopus cyanea* Pp. 267–276 *in*: Boyle, P.R. (ed.), *Cephalopod Life Cycles, Vol. 1, Species Accounts.* London: Academic Press.

Voss, G.L., 1963. Cephalopods of the Philippines. *Smithsonian Institution Bulletin* 234: 1–180, 36 figs.

Voss, G.L. and Solis Ramirez, M., 1966. *Octopus maya*, a new species from the Bay of Campeche, Mexico. *Bulletin of Marine Science* 16 (3): 615–625, 2 figs.

Voss, G.L. and Williamson, G.R., 1971. *Cephalopods of Hong Kong.* Hong Kong Government Press: Hong Kong. 138 pp, 35 pls, 68 figs.

Wilson, B.R. and Allen, G.R., 1987. Major components and distribution of marine fauna Pp. 43–68. *in*: Dyne, G.R. and Watson, D.R. (eds), *Fauna of Australia. General articles Vol. 1A.* Australian Government Publishing Service: Canberra.

Memoirs of the Museum of Victoria 53(2): 345–373 (1992)

REVIEW OF THE *OCTOPUS AUSTRALIS* COMPLEX FROM AUSTRALIA AND NEW ZEALAND, WITH DESCRIPTION OF A NEW SPECIES (MOLLUSCA: CEPHALOPODA)

By T. N. Stranks[1] and M. D. Norman[2]

[1]Department of Invertebrate Zoology, Museum of Victoria, 285–321 Russell Street, Melbourne, Victoria 3000, Australia
[2]Department of Zoology, University of Melbourne, Parkville, Victoria 3052, Australia and, Department of Invertebrate Zoology, Museum of Victoria, 285–321 Russell Street, Melbourne, Victoria 3000, Australia

Abstract

Stranks, T.N. and Norman, M.D., 1992. Review of the *Octopus australis* complex from Australia and New Zealand, with descriptions of a new species (Mollusca: Cephalopoda). *Memoirs of the Museum of Victoria* 53: 345–373.

Four species of shallow water octopuses belonging to the *Octopus australis* complex are reported from Australia and New Zealand. *O. australis* Hoyle, 1885, is redescribed based on the type material and other specimens from subtropical waters of eastern Australia. Three other species are distinguished and characterised: *O. berrima* sp. nov., is diagnosed from temperate waters of south-eastern Australia; and *O. warringa* Stranks, 1990, from temperate waters of Australia and New Zealand, and *O. campbelli* (Smith, 1902) from subantarctic waters off New Zealand, are redescribed.

Introduction

The inshore and deepwater octopodid fauna of Australia is slowly becoming better known. Stranks (1988) revised the inshore octopuses of south-eastern Australia, and together we continue research into the systematics of octopuses of temperate, subtropical and tropical waters of Australia. Stranks (1988: 1990; in press) mentioned problems involving a complex of shallow water species previously attributed to *Octopus australis* Hoyle, 1885. The species within the complex are small to medium sized octopuses with broadly ovoid mantles, long arms, fine and rounded tubercles on the skin, and sometimes a fold or ridge of skin on the ventro-lateral mantle.

The application of the specific name *australis* to Australian and New Zealand taxa is confused. As Tait (1982: 19) stated, "the confusion relating to the identity of *Octopus australis* Hoyle is due largely to the lack of a mature male type specimen." The brief original description of the immature and submature type specimens, and lack of a detailed comparative study of the types, have resulted in the name *O. australis* being applied to several similar taxa from different biogeographic regions.

Three taxa confused with *O. australis*, but now known to constitute separate species, are herein listed as: *O. berrima* sp. nov., *O. campbelli* (Smith, 1902) and *O. warringa* Stranks, 1990. Recent publications dealing with the *O. australis* complex are by Tait (1982), Stranks (1988, 1990), O'Shea (1990) and Toll (1991).

This paper resolves the confusion concerning the four species. Detailed diagnoses, based on type materials plus a comprehensive series of specimens, are provided for two of the taxa (*O. australis* and *O. berrima*). The few available specimens of *O. campbelli* were examined to diagnose this species. Stranks (1988, 1990) provided detailed descriptions of *O. warringa* and the reader is referred to those accounts for information.

Where there is sufficient material, counts and measurements are included for 10 representative females and 10 males. Localities for all specimen lots are mapped. Counts, measurements and indices were defined by Roper and Voss (1983). Measurements and indices are listed throughout as ranges with the mean italicized. Other abbreviations used are: F–female, M–male, ML–mantle length and TL–total length. Material is lodged in collections of: Auckland Institute and Museum, Auckland (AIM); The Australian Museum, Sydney (AM); The Natural History Museum, London (BMNH); Museum of Victoria, Melbourne (NMV); Queensland Museum, Brisbane (QM); Queen Victoria Museum and Art Gallery, Launceston (QVM); South Australian Museum, Adelaide (SAM); and Tasmanian Museum and Art Gallery, Hobart (TM).

Octopodidae

Octopus Lamarck, 1798

Type species. *Octopus vulgaris* Lamarck, 1798.

Diagnosis. Benthic octopodids. Mantle saccular, without fins. 8 arms lacking cirri, arms with biserial suckers, third right arm of males hectocotylised with end of arm modified into ligula and calamus. Web well developed. Ink sac present. Mantle aperture wide. Internal shell cartilaginous and vestigial.

Octopus australis Hoyle

Figures 1–5, 11

Octopus australis Hoyle, 1885a: 224. — 1885b: 98. 1886: 88, pl. 3, figs 4, 5. — Brazier, 1892: 5. — Robson, 1929: 144, text fig. 51 (partim). — Tait, 1982: 15, text figs 1, 2, pl. 1 (partim).

Material examined. See Table 1.

Types. Lectotype (here designated): female, 23.3 mm ML; paralectotype: male, 12.0 mm ML; BMNH 1889.4.24.28-29; preserved in ethyl alcohol.

Type locality. Australia, New South Wales, Port Jackson [33°50'S, 151°17'E], 6–15 fathoms [11–28 m].

Description. Counts, measurements and indices listed in Tables 2–4. Medium sized animals with firm consistency (Fig. 1a). Mantle saccular, broadly ovoid (MWI 56.3–*80.7*–98.5); mantle wall moderately thin, muscular. Head narrow (HWI 41.0–*51.7*–64.6); demarked from mantle by moderate constriction. Eyes small, projecting above surface of head. Funnel large, slender, bluntly tapered (Fig. 1b; FuLI 40.4–*45.7*–54.6); free for about half its length (FFuI 18.0–*27.9*–36.4). Funnel organ consisting of 2 closely opposed V-shaped units; outer limbs approximately as long as median limbs (Fig. 1c). Mantle aperture wide (PAI 71.0–*97.7*–125.5).

Brachial crown strong, well developed. Arms long (MAI 23.4–*31.4*–44.3) (2.7–4.5 times mantle length in mature animals); slender (AWI 6.4–*9.6*–13.6); tapering to fine tips. Arm lengths subequal, arm order usually III,II,IV,I. Suckers biserial, without obvious radial grooves; moderately sized (ASI females 6.3–*9.7*–13.7, males 7.7–*11.2*–15.3); 16th to 20th suckers enlarged on arms II and III of mature males only.

Web formula variable, CDBAE to DCBEA; dorsal and ventral sectors always shallower. Web shallow (WDI 15.3–*22.7*–31.6); web remnants extend up ventral sides of arms for approximately three-quarters of their length.

Third right arm of males hectocotylised (Figs 1d–f); shorter than its opposite number (OAI 72.0–*78.3*–89.0; HcAI 170.5–*232.7*–258.8). Hectocotylised arm with 62–77 suckers; opposite arm with 124–217 suckers. Spermatophoral groove well developed, with conspicuous thickening of web membrane. Ligula 8–17% of hectocotylised arm length in mature animals (LLI 7.5–*12.7*–16.7). Ligula stout, bulbous, with well marked and deep groove, and 2 rows of minute papillae present along the groove. Calamus very short, acutely pointed (CaLI 15.0–*19.5*–29.4).

Gills with 7–9 lamellae on outer demibranch, plus the terminal lamella.

Digestive tract typically octopodan (Fig. 2a). Upper beak has short, blunt, curved rostrum; curved crest; large wings; large lateral walls, with posterior margin deeply indented (Fig. 2b). Lower beak has short, blunt rostrum; long, curved crest; large lateral walls; large wings (Fig. 2c). Rostrum, hood, crest and lateral walls of both upper and lower beaks, heavily pigmented dark brown to black in colour; margins of wings, hood, crest and lateral walls of both beaks transparent. Radula typically octopodan, with 7 transverse rows of teeth and marginal plates (Figs 3c, d). Rhachidian tooth has 1–2 lateral cusps on each side of large medial cusp. Lateral cusps in asymmetrical seriation, migrating from medial to lateral position over 6–7 rows (B_{6-7} type). First lateral teeth small and unicuspidate; second lateral teeth long with curved base; third lateral teeth long and curved; marginal plates rectangular and plain.

Anterior salivary glands small, bordering posterior buccal mass. Posterior salivary glands stout anteriorly, tapering posteriorly, with 1 duct from each gland running forward then uniting to form single duct running alongside oesophagus to buccal mass. Crop with anterior caecum of about 30% of its length. Posterior oesophagus short. Stomach typically bipartite. Caecum with a single loose coil. 2 separate ducts connect digestive gland with caecum. Intestine undifferentiated, although 1 coil occurs midway, but it is not enlarged to form pouch. Ink sac large, lying superficially in groove on ventral face of digestive gland. A short, stout duct connects ink sac with dorsal side of intestine near anus. Anus bears a pair of anal flaps.

Testis posterior in position. Vas deferens long, delicate, tightly coiled, entering spermatophoral gland at proximal end. Spermatophoral gland swollen proximally, with muscular walls, but becoming thin walled towards its junction with the long accessory gland. A short tube connects accessory gland and Needham's sac. Needham's

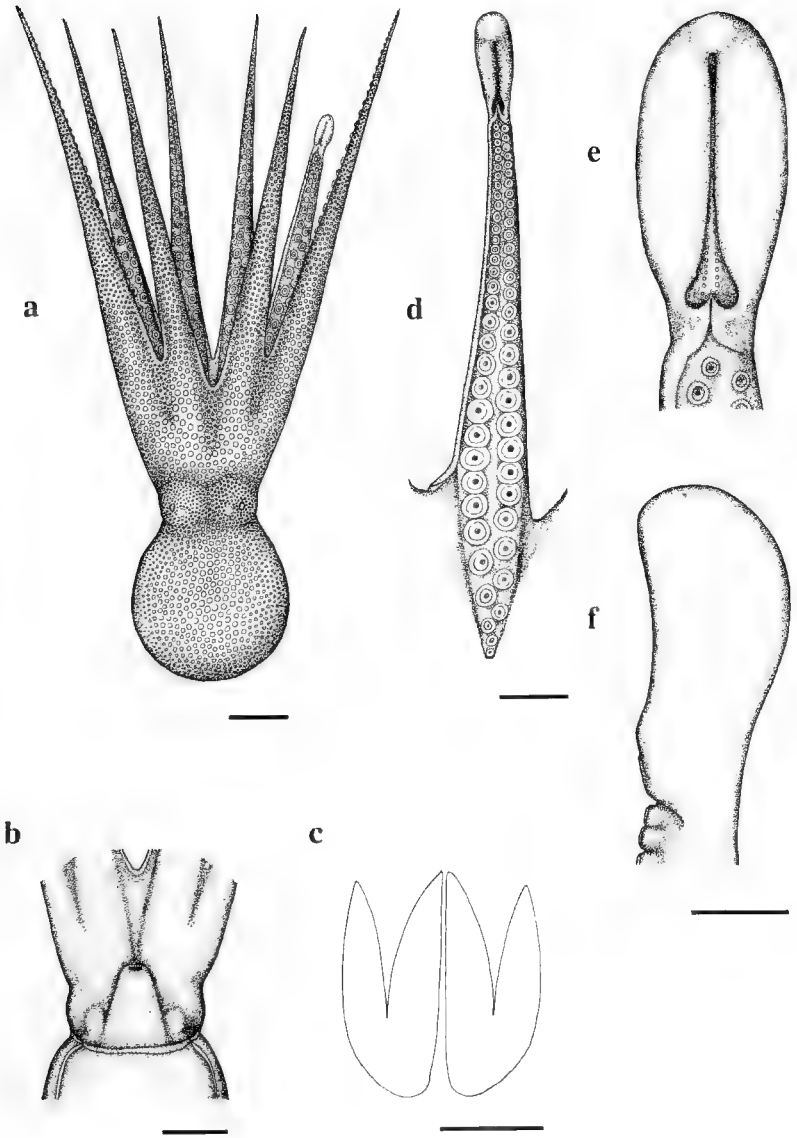


Figure 1. *Octopus australis* Hoyle: a, dorsal view of AM C156204, M, 67.1 mm ML (scale bar = 20 mm); b, ventral view of mantle opening and funnel of AM C156203, F, 50.7 mm ML (scale bar = 10 mm); c, funnel organ of NMV F65533, F, 45.4 mm ML (scale bar = 5 mm); d, hectocotylised arm of AM C166899, 40.5 mm ML (scale bar = 10 mm); e, dorsal, and f, lateral, detail of hectocotylus of NMV F65533, 68.7 mm ML (scale bar = 5 mm).

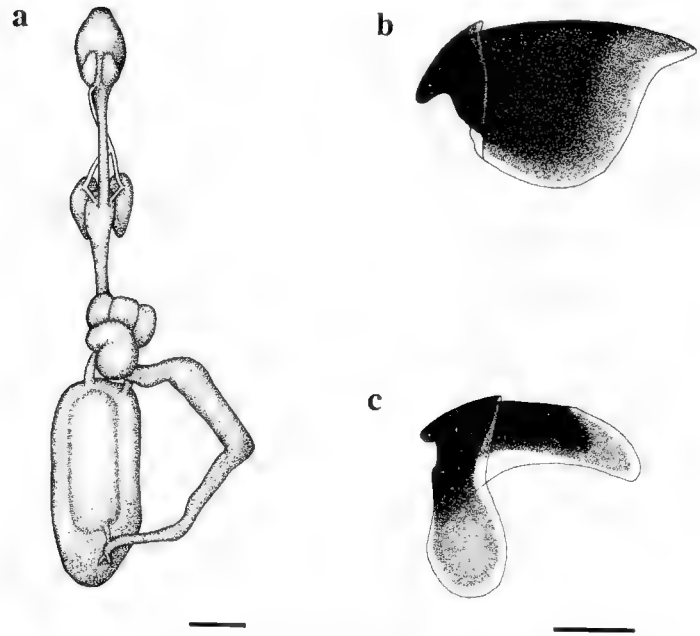


Figure 2. *Octopus australis* Hoyle: a, digestive tract of NMV F65533, M, 63.2 mm ML (scale bar = 10 mm); b, upper beak, and c, lower beak, of NMV F65533, M, 68.7 mm ML (scale bar = 5 mm).

sac long, conical, pointed at apex. Penis long (PLI 16.6–*18.8*–19.8), with a single coiled diverticulum. Genital aperture subterminal, on right side of penis (Figs 4a–c).

Spermatophores relatively long (SpLI 62.6–*73.7*–84.7), slender (SpWI 1.6–*2.5*–3.7) (Figs 4d–g). Oral cap simple, expanded, with a long cap thread. Ejaculatory apparatus is a tightly coiled tube, which narrows orally, with 2–3 coils close to the oral end. Small, bulbous cement body connects with both oral and aboral ends by narrow necks. Sperm reservoir spirally wound with a rounded aboral end; comprises approximately half of the spermatophore length (SpRI 34.7–*42.7*–55.6); forms widest region of spermatophore.

Ovary large, ovoid, displacing adjacent organs when mature (Fig. 5a). Proximal oviducts initially common, then dividing into 2 long, curved ducts. Oviducts attach to spherical oviductal glands, which are darker in colour. Distal oviducts straight, tapering gradually. No females were observing brooding eggs. Mature eggs from females with enlarged ovaries (NMV F65533: 54 mm, 62 mm, 65 mm ML) are large (8–12 mm long; 1.5–2.0 mm wide), yellow, translucent, with egg striation (EgLI 13.7–*17.0*–21.4; EgWI 2.6–*3.2*–4.4). Method of egg attachment unknown.

Integumental sculpture consists of a pattern of fine, rounded and closely set epidermal tubercles. The tubercles are largest and most dense on the dorsum; those on the ventral surface are similarly sized but more scattered. Unbranched papillae present in ocular region (Fig. 5b), with a row of 1 large and 3–4 small supraocular papillae. Ventrolateral integumentary ridge present on mantle; ridge obvious and continuous around entire mantle circumference, with the ridge forming an sharply angled peak on the posterior mantle (Figs 5c, d).

Colour of live animals unknown. Colour of specimens preserved in ethanol uniformly light brown to purple dorsally, cream to light brown ventrally. Ocelli absent.

Males mature at approximately 20–25 mm ML. Females attain ovarian maturity at about 50–60 mm ML. The largest specimen studied

Table 1. Material examined: *Octopus australis* Hoyle, 1885.

Status	Sex	ML (mm)	Reg. No.	Locality	Date	Depth (m)	Collector
Lectotype	1F	23.3	BMNH 1889.4.24.28-29	Port Jackson, NSW [33°50′S, 151°17′E]	Apr 1874	11–28	HMS "Challenger"
Paralectotype	1M	12.0	BMNH 1889.4.24.28-29	Port Jackson, NSW [33°50′S, 151°17′E]	Apr 1874	11–28	HMS "Challenger"
Other Material	1M	18.3	AM C166898	34°36′S, 151°03′E	5 Nov 1981	128–134	FRV "Kapala"
	1M	27.1	AM C170007	Port Jackson, NSW [33°50′S, 151°17′E]	—	—	—
	1F	30.4	AM C36592	Port Jackson, NSW [33°50′S, 151°17′E]	—	—	—
	1F	30.7	QM Mo36049	Moreton Bay, Qld [27°25′S, 153°20′E]	9 Dec 1921	—	K. Kandler
	1F	37.9	NMV F65532	27°42′S, 153°35′E	6 Nov 1981	57	FV "Iron Summer"
	1M	40.5	AM C166899	Sydney Harbour, NSW [33°50′S, 151°17′E]	—	—	Capt Comtesse
	1M	45.2	QM Mo4105	off Point Cartwright, Qld [26°41′S, 153°08′E]	7 Mar 1970	35–38	F. Wallace
	4M,5F	45.4–68.7	NMV F65533	27°45′S, 153°40′E	6 Nov 1981	83	FV "Iron Summer"
	1M	46.5	AM C71014	26°45′S, 153°21′E	27 Jul 1968	46–48	Qld Fish. Res. Inst.
	1F	50.7	AM C156203	Kurnell, Botany Bay, NSW [34°00′S, 151°50′E]	14 Oct 1974	5	CSIRO
	1M	60.4	AM C36580	Newcastle Bight, NSW [32°55′S, 151°50′E]	2 Mar 1898	29–35	HMCS "Thetis"
	1M	67.1	AM C156204	Kurnell, Botany Bay, NSW [34°00′S, 151°13′E]	18 Mar 1975	3	CSIRO
	1F	71.7	AM C36577	off Newcastle, NSW [32°55′S, 151°50′E]	4 Mar 1898	77–88	HMCS "Thetis"

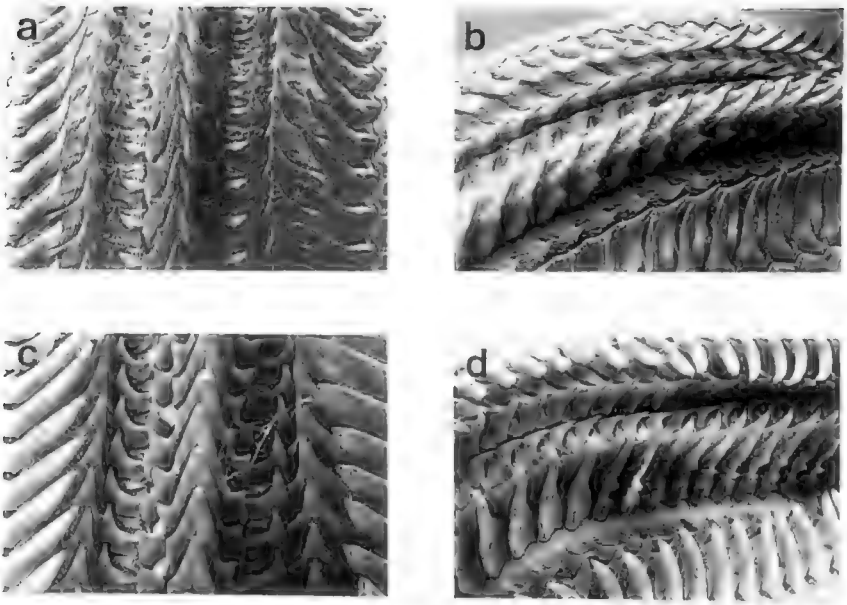


Figure 3. *Octopus berrima* sp. nov.: a and b, radula of NMV F31264, M, 71.4 mm ML. *Octopus australis* Hoyle: c and d, radula of NMV F65533, M, 68.7 mm ML.

was a female of 72 mm ML from off Newcastle, NSW (AM C36577).

Distribution. Eastern Australia, from Hervey Bay, Queensland (about 25°S) to Jervis Bay, New South Wales (about 35°S) (Fig. 11). Bathymetric records range from 3 to 134 m. The species is common in subtropical inshore waters, living on sand and mud bottom, and among sponges.

Remarks. Hoyle (1885a) described *O. australis* based on specimens collected in eastern Australia during the cruise of HMS "Challenger" (1873-1876). Additional details appeared in a following paper (Hoyle, 1885b), which was then again expanded with the inclusion of measurements and illustrations (Hoyle, 1886). Hoyle (1886) provided some details of what is now designated to be the submature female lectotype, but did not give any data on the immature male paralectotype.

Brazier (1892) later recorded *O. australis* from Georges Beach, NSW. To that date, *O. australis* had been recorded from two localities in NSW. Subsequently, the name *O. australis* was only employed for the morphologically similar, but distinct, species from south-eastern Australia, herein named *O. berrima* (see separate entry). From the 1890s to the present, the species now identified as occurring in NSW and Queensland waters was considered unnamed.

Robson (1929) and Tait (1982) had opportunities to examine in detail the type specimens of *O. australis*, and both authors continued usage of the name for the south-eastern Australian species. It was not until the present authors had begun a study of the eastern Australian octopodid fauna, and comparative work carried out between eastern and southern Australian octopuses, that the applicability of the name *O. australis* to the eastern and not the southern species was realised.

The present determination and redescription is based on examination of the two type specimens and 31 other specimen lots of *O. australis*, from the collections of the AM, BMNH, NMV and QM.

The morphology and measurements of the

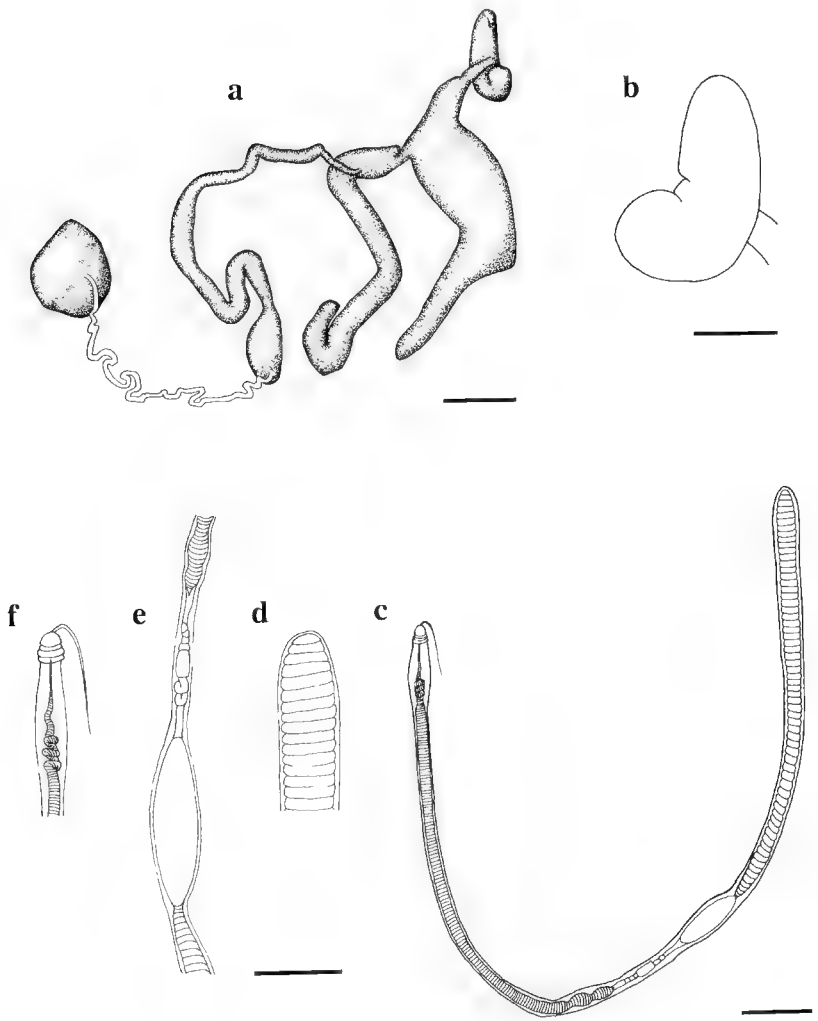


Figure 4. *Octopus australis* Hoyle: a, male reproductive organs (scale bar = 10 mm), b, penis (scale bar = 2 mm), and c–f, spermatophore, of NMV F65533, 57.6 mm ML: c, whole spermatophore (scale bar = 2 mm); d, aboral end of sperm reservoir; e, spermatophore midsection, cement body to sperm reservoir; f, oral cap and cap thread (scale bar = 1 mm).

Table 2. Measurements (mm) and indices of 10 female *Octopus australis* Hoyle, 1885. (S = submature; M = mature; * = arm severed or regenerated).

Museum Reg. No.	AM C36592	QM Mo36049	NMV F65532	NMV F65533	AM C156203	NMV F65533	NMV F65533	NMV F65533	NMV F65533	AM C36577
ML	30.4	30.7	37.9	45.4	50.7	53.0	54.3	62.1	64.9	71.7
StM	S	S	S	S	S	S	M	M	M	M
TL	125.3	139.5	207.5	229.5	197.2	264.5	237.5	237.5	282.3	282.0
MWI	92.1	69.4	96.3	90.1	75.5	94.3	85.3	75.4	83.8	80.5
HWI	63.5	52.1	63.1	53.1	51.7	51.9	49.9	41.9	45.9	44.9
MAI	33.3	29.7	23.4	24.9	33.9	25.7	31.1	31.7	29.8	33.2
ALI: 1	250.7	281.8	379.9	346.3	243.2	347.9	176.4*	276.2	284.7	263.6
2	299.3	312.7*	423.5	389.4	277.1	389.6	321.0	305.2	329.0	301.3
3	300.3	307.8	427.4	401.3	294.9	377.9	317.3	315.3	335.1	288.7
4	287.8	337.1	388.9	381.9	276.7	360.4	321.4	305.2	313.1	281.7
AWI	12.5	10.4	9.8	10.1	10.8	9.2	9.4	8.5	8.3	6.4
ASI	8.6–11.2	11.7–13.7	9.5–12.7	9.3–11.2	8.7–10.7	9.1–10.9	7.9–10.1	6.9–9.8	6.3–9.6	7.4–9.1
WDI	26.2	15.3	20.7	21.2	25.3	20.1	22.4	22.1	20.0	21.3
WF	DCBEA	CDBAE	CDBEA	CDBEA	CDBEA	DCBEA	DCBEA	CDBEA	CDBEA	DCBEA
GiLC	8	7	8	8	8	8	8	8	8	8
EgLI	6.3	5.2	6.3	7.7	10.1	7.9	21.4	15.3	17.7	9.5
EgWI	1.0	2.0	0.8	1.3	1.6	1.7	4.4	3.1	2.9	2.1
FuLI	54.6	41.7	54.6	45.8	46.7	43.4	45.7	42.2	45.1	43.2
FFuI	27.3	18.9	31.7	28.6	29.4	35.5	28.0	25.6	28.0	27.9
PAI	83.2	102.3	113.2	122.2	87.4	125.5	107.7	95.8	103.2	84.9

Table 3. Measurements (mm) and indices of 10 male *Octopus australis* Hoyle, 1885. (Imm = immature; M = mature; * = arm severed or regenerated).

Museum Reg. No.	AM C166898	AM C170007	AM C166899	QM Mo4105	AM C71014	NMV F65533	NMV F65533	AM C36580	AM C156204	NMV F65533
ML	18.3	27.1	40.5	45.2	46.5	57.6	58.2	60.4	67.1	68.7
StM	Imm	M	M	M	M	M	M	M	M	M
TL	61.0	111.5	148.2	202.0	195.0	263.5	258.8	254.0	249.5	298.5
MWI	56.3	88.9	81.7	81.6	69.9	82.8	77.3	98.5	68.1	65.9
HWI	52.5	64.6	51.1	51.1	51.2	49.8	54.5	54.0	46.6	41.0
MAI	44.3	32.6	37.1	29.2	31.0	28.6	29.7	30.5	36.9	31.1
ALI: 1	193.4	238.0	121.5*	298.7	289.2	294.8	278.0	293.0	243.7	290.4*
2	225.7	307.0	269.6	331.9	139.4*	335.9	336.4	317.9	270.8	305.7
3	216.4	281.2	221.0*	342.9	323.0	349.7	305.0	317.9	263.3	321.7*
4	188.5	280.4	263.0	329.6	320.4	338.5	280.9	327.8	263.0	296.2*
AWI	6.6	12.9	10.1	8.4	7.3	11.5	9.3	8.3	13.6	9.5
ASI	7.7–11.5	8.9–12.9	8.6–12.6	10.0–12.8	9.0–14.2	9.4–13.7	8.4–13.4	9.9–14.1	9.4–13.7	8.6–15.3
WDI	19.6	28.0	25.0	24.2	22.6	20.1	24.1	22.4	31.6	—
WF	CDBEA	DCBEA	B=C=DEA	DCBEA	DCBEA	CDBEA	DCBEA	DCB=EA	DCBEA	CDBEA
GiLC	8	8	8	8	9	8	8	8	8	8
HcAI	170.5	250.2	224.2	258.8	239.8	253.8	219.6	251.7	224.0	234.4
OAI	78.8	89.0	—	75.5	74.2	72.6	72.0	79.2	85.1	—
LLI	16.7	7.5	16.1	11.7	13.4	12.4	11.9	13.2	11.2	12.4
CaLI	25.0	29.4	15.8	20.4	15.4	17.1	20.4	15.0	18.5	18.1
HASC	35	70	62	74	77	73	66	70	68	67
PLI	18.6	16.6	16.8	19.7	19.6	19.6	19.8	19.5	19.8	17.6
SpLI	—	71.6	84.4	84.1	84.7	72.7	68.2	86.1	72.3	65.5
SpWI	—	3.1	3.7	2.8	2.7	1.7	2.5	2.8	2.5	2.1
SpRI	—	38.1	38.6	36.8	40.6	40.1	50.7	44.8	48.2	55.6
FuLI	50.3	48.7	48.4	46.9	41.3	45.5	40.4	50.3	40.5	39.6
FFuI	26.8	26.9	18.0	31.4	28.0	28.6	29.6	36.4	27.5	24.0
PAI	71.0	100.7	92.1	112.8	90.8	89.1	91.9	105.6	85.7	88.1

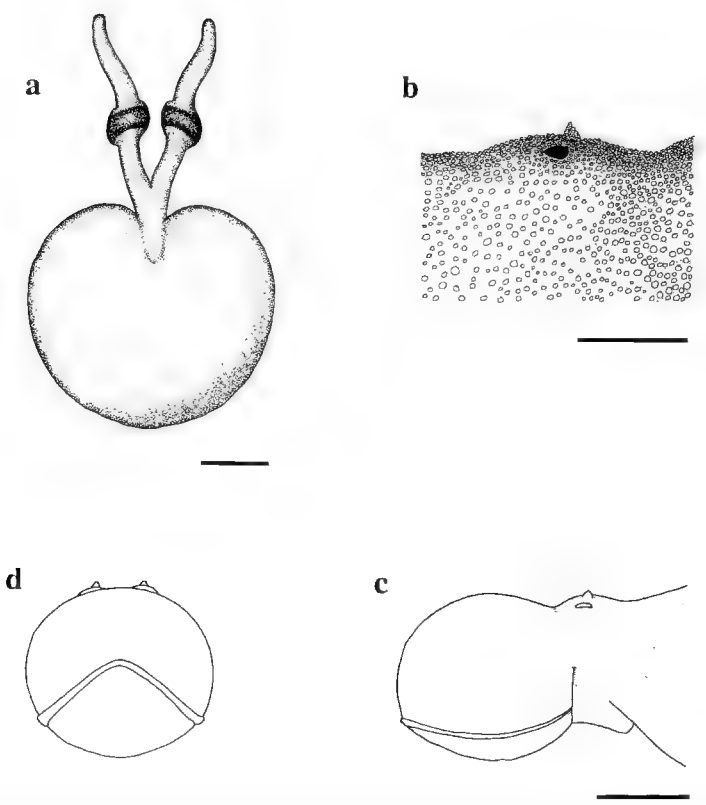


Figure 5. *Octopus australis* Hoyle: a, female reproductive organs of NMV F65533, 54.3 mm ML (scale bar = 10 mm); b, lateral view of unbranched ocular papillae (scale bar = 10 mm), c, lateral view, and d, posterior view, of mantle and ventrolateral integumentary ridge (scale bar = 20 mm), of NMV F65533, F, 45.4 mm ML.

immature male and submature female syntypes of *O. australis* fall largely within the ranges of variation from the sample of 10 females and 10 males from eastern Australia (see Table 4). Any significant discrepancies in morphometry between the type specimens and the larger sample (such as with the MAI, ALI, LLI, EgLI and EgWI indices) may be attributed to allometric variablity.

Octopus australis can be distinguished from other species of the genus on the basis of the following characters: a broadly ovoid mantle; skin with a pattern of fine, rounded and closely set tubercles on the dorsum, a continuous ventrolateral ridge around the mantle, and a large papilla over each eye; small but prominent eyes; long, subequal arms (2.7–4.5 times ML in mature animals); moderately large suckers, with 4–5 suckers slightly enlarged on the lateral arms of males only; a medium sized, stout, bulbous ligula (8–17% of third right arm length), and a very short calamus; large eggs (8–12 mm long), with unknown method of attachment to substrate; and 7–9 gill lamellae.

This species is common in inshore waters of eastern Australia, where it is frequently taken as a commercial by-catch by prawn trawlers operating in northern New South Wales and southern Queensland waters. Examination of catches by one of us (TNS) shows that the species

Table 4. Measurements (mm) and indices of types (BMNH 1889.4.24.28-29); and combined ranges, means and standard deviations of indices from another 10 males and females of *Octopus australis* Hoyle, 1885.
(Imm = immature; S = submature; * = arm severed or regenerated).

Museum Reg. No.	BMNH 1889.4.24.28-29 (Lectotype)	BMNH 1889.4.24.28-29 (Paralectotype)	Other material Range and mean	s.d.
ML	23.3	12.0		
StM	S	Imm		
TL	88.2	38.1		
MWI	84.5	80.8	56.3–*80.7*–98.5	(11.1)
HWI	56.2	63.3	41.0–*51.7*–64.6	(6.4)
MAI	36.1	45.5	23.4–*31.4*–44.3	(4.6)
ALI: 1	229.6	190.8	192.3–*277.9*–379.9	(43.9)
2	267.4	210.8	203.8–*312.1*–423.5	(48.2)
3	277.3	207.5	216.4–*318.0*–427.4	(49.2)
4	236.9	220.0	182.5–*303.2*–388.9	(48.8)
AWI	12.4	12.5	6.4–*9.6*–13.6	(2.0)
ASI: F	10.7		6.3–*9.7*–13.7	(1.9)
M		10.0	7.7–*11.2*–15.3	(2.4)
WDI	27.4	31.8	15.3–*22.7*–31.6	(3.6)
WF	CD=BEA	CBDEA		
GiLC	9	9		
EgLI	3.0		13.7–*17.0*–21.4	(2.7)
EgWI	1.3		2.6–*3.2*–4.4	(0.7)
HcAI		190.8	170.5–*232.7*–258.8	(25.9)
OAI		92.0	72.0–*78.3*–89.0	(6.1)
LLI		3.1	7.5–*12.7*–16.7	(2.6)
CaLI		14.3	15.0–*19.5*–29.4	(4.6)
HASC		60		
PLI		16.7	16.6–*18.8*–19.8	(1.3)
SpLI		—	62.6–*73.7*–84.7	(8.1)
SpWI		—	1.6–*2.5*–3.7	(0.6)
SpRI		—	34.7–*42.7*–55.6	(6.4)
FuLI		47.5	40.4–*45.7*–54.6	(4.4)
FFuI	40.2	49.1	18.0–*27.9*–36.4	(4.4)
PAI	86.3	111.7	71.0–*97.7*–125.5	(13.9)

constitutes a high percentage of the total octopus fisheries yield from the region, which has been estimated during recent years to be 150 000 kg (unpublished data, Bureau of Rural Resources, Canberra). Nothing is known of the general biology of the species.

Octopus berrima sp. nov.

Figures 3, 6–11

Octopus australis. — Pritchard and Gatliff, 1898: 241. — Robson, 1929: 144, text fig. 51 (partim). — Cotton, 1939: 165. — Cotton and Godfrey, 1940: 447, text figs 429–431 (partim). — Macpherson and Gabriel, 1962: 415 (partim). — Macpherson, 1966: 241. — Tait, 1982: 15, text figs 1, 2, pl. 1 (partim). — Stranks, 1988: 23, text figs 1–5.

Polypus cf. *australis*. — Berry, 1918: 276, text fig. 62, pl. 78, figs 1, 2, pl. 81, fig. 1 (partim).

Octopus superciliosus. — Macpherson, 1966: 244, pl. 3, figs 1, 2, pl. 4, figs 1–4, pl. 5, figs 1-4 (partim) (non *Octopus superciliosus* Quoy and Gaimard, 1832).

Material examined. See Table 5.

Holotype. Male, 58.9 mm ML, NMV F67132; preserved in ethyl alcohol.

Type locality. Australia, Victoria, Port Phillip Bay, off Mordialloc (38°02′S, 145°05′E), depth unknown.

Description. Counts, measurements and indices listed in Tables 6–8. Medium sized animals with

firm consistency (Fig. 6a). Mantle saccular, broadly ovoid (MWI 35.5–*73.8*–92.9); mantle wall moderately thin, muscular. Head narrow (HWI 26.8–*48.6*–68.3); demarked from mantle by moderate constriction. Eyes small, projecting above surface of head. Funnel large, slender, bluntly tapered (Fig. 6b; FuLI 31.2–*45.4*–52.4); free for about half its length (FFuI 17.8–*27.5*–37.7). Funnel organ consisting of 2 closely opposed V-shaped units which may be partially fused medially; outer limbs approximately three-quarters as long as median limbs (Fig. 6c). Mantle aperture wide (PAI 60.8–*99.1*–114.1).

Brachial crown strong, well developed. Arms long (MAI 25.1–*34.1*–50.3) (1.9–4.1 times ML in mature animals); slender (AWI 5.3–*8.9*–15.8); tapering to fine tips. Arm lengths subequal; arm order usually II.III.IV.I or III.II.IV.I. Suckers biserial, without obvious radial grooves; moderately sized (ASI 3.3–*7.3*–13.1); 12th to 20th suckers usually largest; without conspicuous sucker enlargement.

Web formula variable, CDBAE to DCBEA; dorsal and ventral sectors always shallower. Web shallow (WDI 19.8–*24.4*–32.2); web remnants extend up ventral sides of arms for approximately three-quarters of their length.

Third right arm of males hectocotylised (Figs 6d–f); shorter than its opposite number (OAI 63.0–*79.9*–97.0; HcAI 196.4–*246.6*–293.6). Hectocotylised arm with 66–78 suckers; opposite arm with 138–218 suckers. Spermatophoral groove well developed, with conspicuous thickening of web membrane. Ligula 11–16% of hectocotylised arm length in mature animals; usually recurved orally (LLI 10.9–*13.3*–15.5). Ligula conical, elongate, with well marked and deep groove, and 2 rows of minute papillae present along the groove. Calamus very short, acutely pointed (CaLI 15.3–*17.2*–20.2).

Gills with 7–8 lamellae on outer demibranch, plus the terminal lamella.

Digestive tract typically octopodan (Fig. 7a). Upper beak has short, blunt, curved rostrum; curved crest; large wings; large lateral walls, with posterior margin deeply indented (Fig. 7b). Lower beak has short, blunt rostrum; long, curved crest; large lateral walls; large wings (Fig. 7c). Rostrum, hood, crest and lateral walls of both upper and lower beaks, heavily pigmented dark brown to black in colour; margins of wings, hood, crest and lateral walls of both beaks transparent. Radula typically octopodan, with 7 transverse rows of teeth and marginal plates (Figs 3a, b). Rhachidian tooth has 1–2 lateral cusps on each side of large medial cusp. Lateral cusps in asymmetrical seriation, migrating from medial to lateral position over 3–4 rows (B_{3-4} type). First lateral teeth small and unicuspidate; second lateral teeth long with curved base; third lateral teeth long and curved; marginal plates rectangular and plain.

Anterior salivary glands small, bordering posterior buccal mass. Posterior salivary glands stout anteriorly, tapering posteriorly, with 1 duct from each gland running forward then uniting to form single duct running alongside oesophagus to buccal mass. Crop with anterior caecum of about 30% of its length. Posterior oesophagus short. Stomach typically bipartite. Caecum with a single loose coil. 2 separate ducts connect digestive gland with caecum. Intestine undifferentiated, although 1 coil occurs midway, but it is not enlarged to form pouch. Ink sac large, lying superficially in groove on ventral face of digestive gland. A short, stout duct connects ink sac with dorsal side of intestine near anus. Anus bears a pair of anal flaps.

Testis posterior in position. Vas deferens long, delicate, tightly coiled, entering spermatophoral gland at proximal end. Spermatophoral gland swollen proximally, with muscular walls, but becoming thin walled towards its junction with the long accessory gland. A short tube connects accessory gland and Needham's sac. Needham's sac long, conical, pointed at apex. Penis long (PLI 14.2–*25.2*–30.6), with a single coiled diverticulum. Genital aperture subterminal, on right side of penis (Figs 8a–c).

Spermatophores relatively long (SpLI 56.7–*87.3*–125.2), slender (SpWI 1.9–*2.6*–3.0) (Figs 8d–g). Oral cap simple, expanded, with a long cap thread. Ejaculatory apparatus is a tightly coiled tube, which narrows orally, without coils near the oral end. Small, bulbous cement body connects with both oral and aboral ends by narrow necks. Sperm reservoir spirally wound with a rounded aboral end; comprises approximately half of the spermatophore length (SpRI 37.5–*43.1*–50.2); forms widest region of spermatophore.

Ovary large, ovoid, displacing adjacent organs when mature (Fig. 9a). Proximal oviducts initially common, then dividing into 2 long, curved ducts. Oviducts attach to spherical oviductal glands, which are darker in colour. Distal oviducts tapering gradually. 1 female (NMV F52511) observed brooding eggs. Mature eggs large (10–14 mm long; 4–5 mm wide), white, translucent (Fig. 10e; EgLI 11.0–*17.3*–23.1;

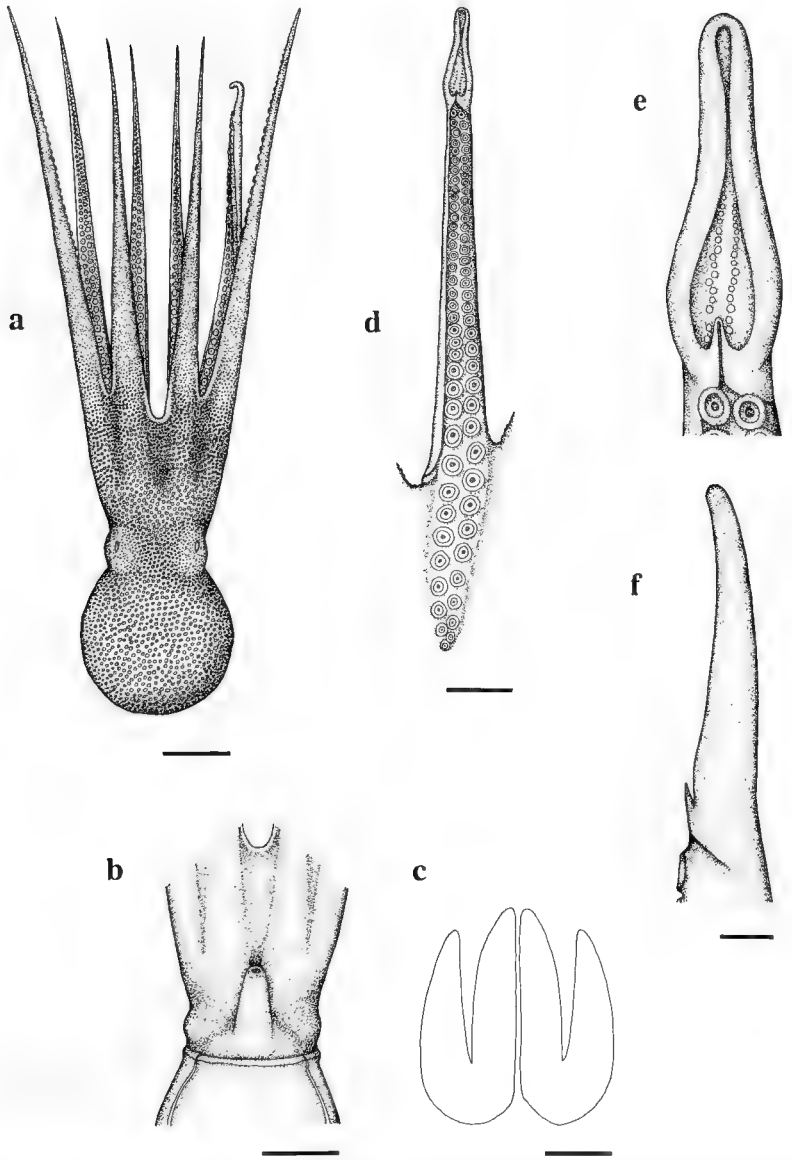


Figure 6. *Octopus berrima* sp. nov.: a, dorsal view of NMV F52509, M, 31.3 mm ML (scale bar = 10 mm); b, ventral view of mantle opening and funnel of SAM D18775, paratype, M, 36.3 mm ML (scale bar = 10 mm); c, funnel organ of NMV F67132, holotype, M, 58.9 mm ML (scale bar = 5 mm); d, hectocotylised arm (scale bar = 10 mm), e, dorsal, and f, lateral, detail of hectocotylus (scale bar = 2 mm), of SAM D18775, paratype, 36.3 mm ML.

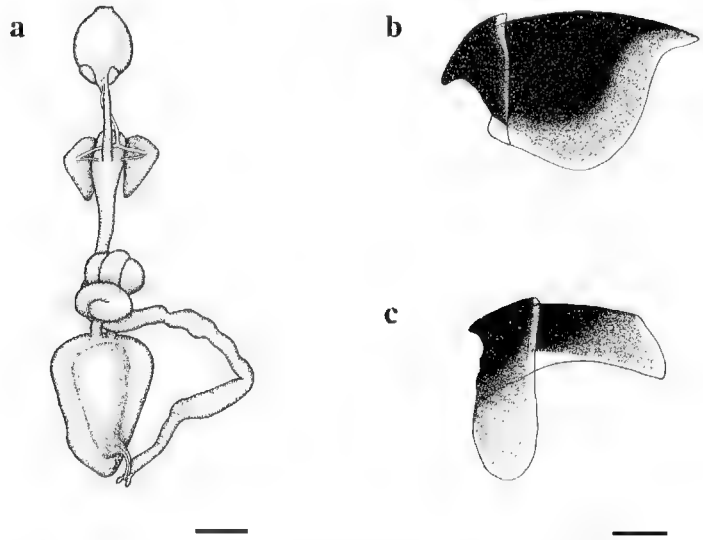


Figure 7. *Octopus berrima* sp. nov.: a, digestive tract of NMV F52509, M, 31.3 mm ML (scale bar = 5 mm); b, upper beak, and c, lower beak, of NMV F67132, holotype, M, 58.9 mm ML (scale bar = 2 mm).

EgWI 2.5–4.2–5.7). Eggs attached singly to substrate by long thin stalks (5–8 mm long). Egg striation absent.

Integumental sculpture consists of a pattern of fine, rounded and closely set epidermal tubercles. The tubercles are largest and most dense on the dorsum; those on the ventral surface are smaller and less prominent. Unbranched papillae present in ocular region with a row of 1 large and 3–4 small supraocular papillae (Fig. 9b), and on the mantle dorsum with 4 primary papillae in a diamond arrangement. Ventrolateral integumentary ridge present around mantle circumference; ridge obvious near pallial aperture, but less obvious posteriorly, where the ridge runs more or less straight around the posterior mantle (Figs 9c, d).

In life, colour of resting animals grey white with light brown mottling dorsally, white to pale cream ventrally. Lateral body bar of dark brown colour runs from posterior of each eye, passing through eye, to brachial crown. When stimulated, animals become darker in colour, uniformly dark brown to purple brown dorsally, cream to light brown ventrally. Posterior white spots consisting of 2 spots on dorsal mantle, posterior to eyes. White bar present between eyes. Frontal white spots consisting of 2 thin stripes along basal length of dorsal arms (Figs 10a–d). Ocelli absent.

Males mature at approximately 20–25 mm ML; females attain ovarian maturity at about 30–40 mm ML (Tait, 1982). The largest specimen studied was a male of 106 mm ML from off Stanley, Tasmania (NMV F52515).

Distribution. South-eastern Australia, from the central Great Australian Bight (about 132°E) to Twofold Bay, NSW (about 37°S), including Bass Strait and Tasmania (Fig. 11). Bathymetric records range from 5 to 267 m. The species is common in temperate inshore waters, living on sand and mud bottom, and among sponges and ascidians.

Etymology. The specific epithet *berrima* is derived from an Australian Aboriginal word meaning "to the south," and is to be treated as indeclinable.

Remarks. Octopus berrima has been previously incorrectly identified and described under the name *O. australis* Hoyle, 1885. The latter name was established for a species described from Port Jackson, NSW, but now known to occur in waters from central NSW to southern Queens-

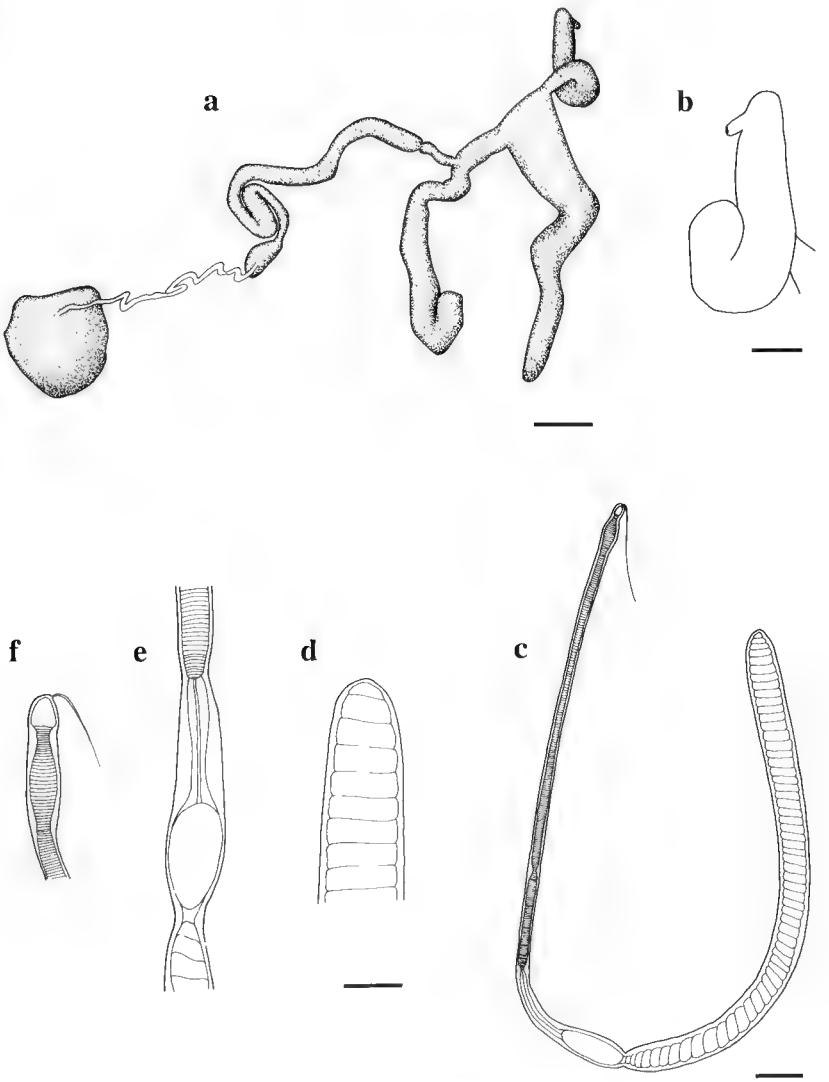


Figure 8. *Octopus berrima* sp. nov.: a, male reproductive organs (scale bar = 5 mm), and b, penis (scale bar = 2 mm), of SAM D18775, paratype, 36.3 mm ML; c–f, spermatophore from NMV F31002, 70.6 mm ML; c, whole spermatophore (scale bar = 2 mm); d, aboral end of sperm reservoir; e, spermatophore midsection, cement body to sperm reservoir; f, oral cap and cap thread (scale bar = 1 mm).

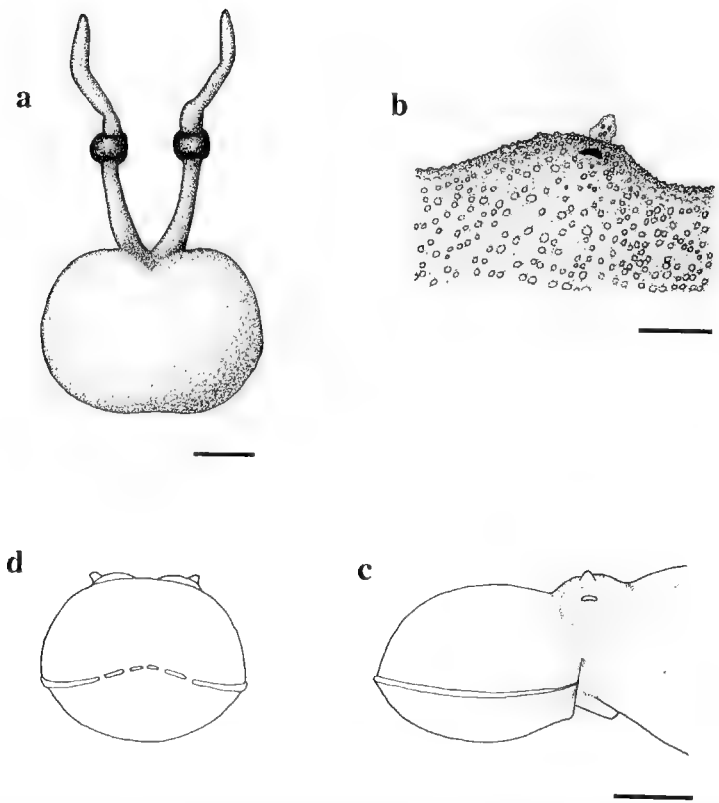


Figure 9. *Octopus berrima* sp. nov.: a, female reproductive organs of NMV F52514, paratype, 56.2 mm ML (scale bar = 10 mm); b, lateral view of unbranched ocular papilla of SAM D18775, paratype, M, 36.3 mm ML (scale bar = 5 mm); c, lateral view, and d, posterior view, of mantle and ventrolateral integumentary ridge of NMV F52509, M, 31.3 mm ML (scale bar = 31.3 mm ML).

land (see separate entry). Pritchard and Gatliff (1898) recorded *O. australis* in a faunal list from Port Phillip Heads, Victoria, but the material on which this identification was based is unknown. Since that date the name *O. australis* has been persistently and erroneously used for a separate and distinct south-eastern Australian species, instead of the eastern Australian taxon.

This description of *O. berrima* was based on examination of 176 specimen lots from collections of the AM, NMV, SAM, QVM and TM.

Octopus berrima can be distinguished from other species of the genus with a combination of characters: a broadly ovoid mantle; skin with a pattern of very fine, rounded and closely set tubercles on the dorsum, a ventrolateral ridge extending partway around the mantle, and a large papilla over each eye; small but prominent eyes; long, subequal arms (2–4 times ML in mature animals); moderately large suckers, without enlargement; a medium sized, elongated, conical ligula (11–16% of third right arm length), and a very short calamus; large eggs (10–14 mm long), attached singly to substrate; and 7–8 gill lamellae.

Growth, reproduction and diet of *O. berrima* (under the name *O. australis*) were studied by Tait (1980). Females brood 50–130 eggs for at

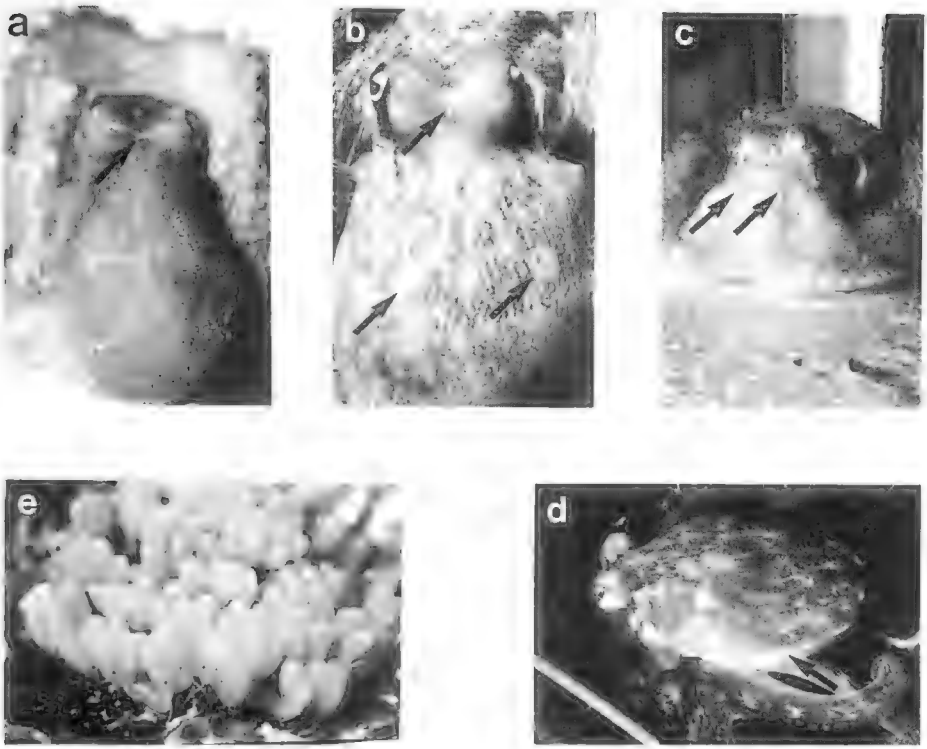


Figure 10. *Octopus berrima* sp. nov.: a, dorsal view of body showing white head bar (NMV F67133, 63.4 mm ML); b, dorsal view of body exhibiting white head bar and mantle white spots, c, anterior view of body and arms showing brachial crown white stripes, and d, view of body exhibiting ventrolateral integumentary ridge (NMV F67134, 61.8 mm ML); e, eggs (10–14 mm long) attached singly to valve of *Ostrea angasi* (photograph by R. Day) (Adelaide, South Australia).

least 100 days during summer. Hatchlings grow to a maximum size after 18–20 months. The species is an opportunistic predator, feeding mainly on isopod crustaceans, with other crustaceans, gastropods, bivalves, polychaetes and octopus forming a lesser component of the diet (Tait, 1980).

O. berrima is common in inshore waters of south-eastern Australia. The species is caught incidentally during scallop and mussel dredging, and seine netting; catches are mainly utilised as bait in the longline fishery for snapper, *Chrysophrys auratus* (Winstanley et al., 1983, as *O. australis*; personal observations).

Octopus campbelli (Smith)

Figures 12–14

Polypus campbelli Smith, 1902: 201, pl. 24, figs 7–11. — Suter, 1913: 1063, pl. 69, fig. 3.

Joubinia campbelli. — Robson, 1929: 190, text figs 73, 74.

Robsonella australis. — Benham, 1942: 227, text fig. 3, pls 18, 19 (partim). — Dell, 1952: 32, pl. 4, figs 2–6, pl. 5, figs 1, 3, 4, pls 7, 8 (partim) (non *Octopus australis* Hoyle, 1885).

Robsonella campbelli. — O'Shea, 1990: 65, text figs 6.1–6.8.

Material examined. Holotype: New Zealand, Camp-

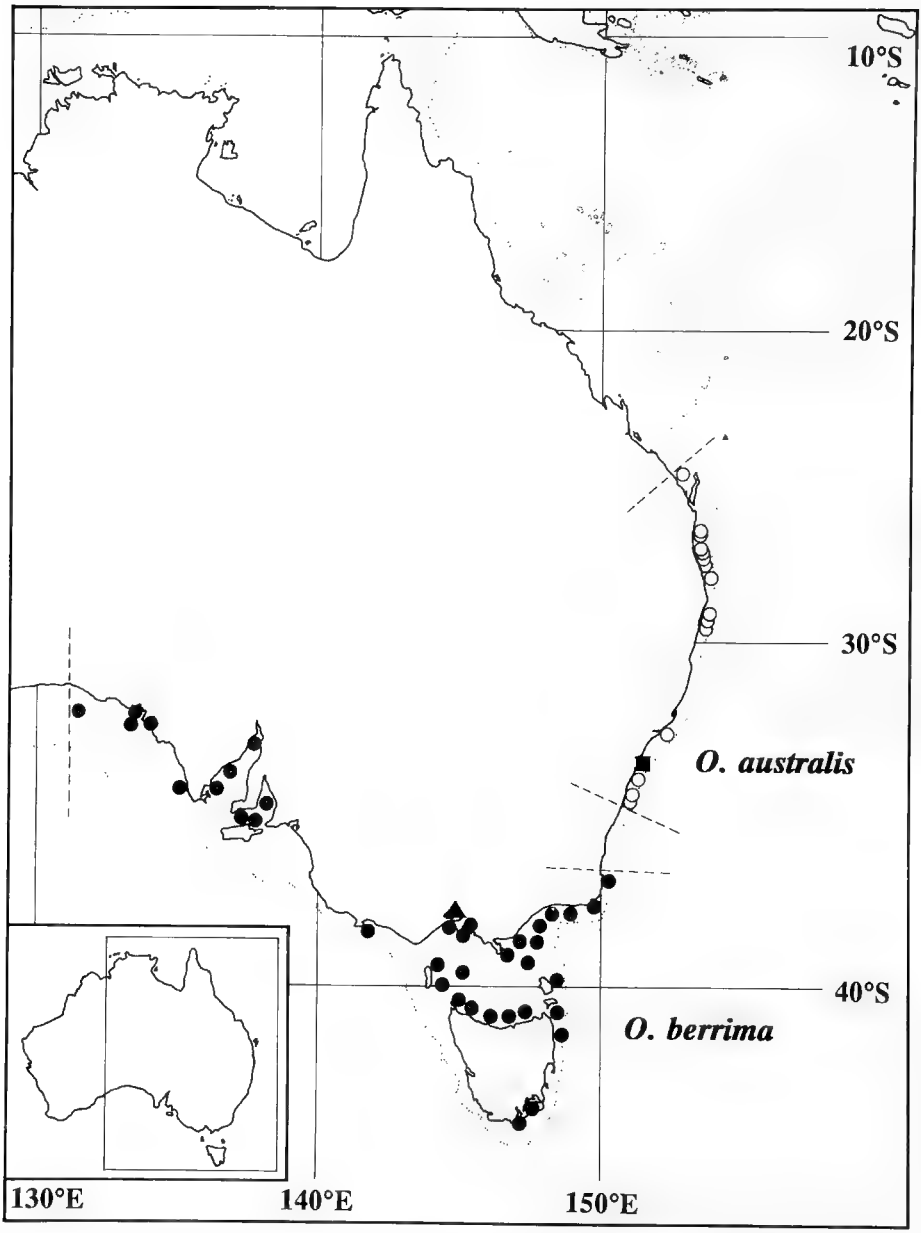


Figure 11. Geographical distribution of *Octopus australis* Hoyle in eastern Australia (■ = type locality; ○ = localities of other material), and *Octopus berrima* sp. nov. in south-eastern Australia (▲ = type locality; ● = localities of other material).

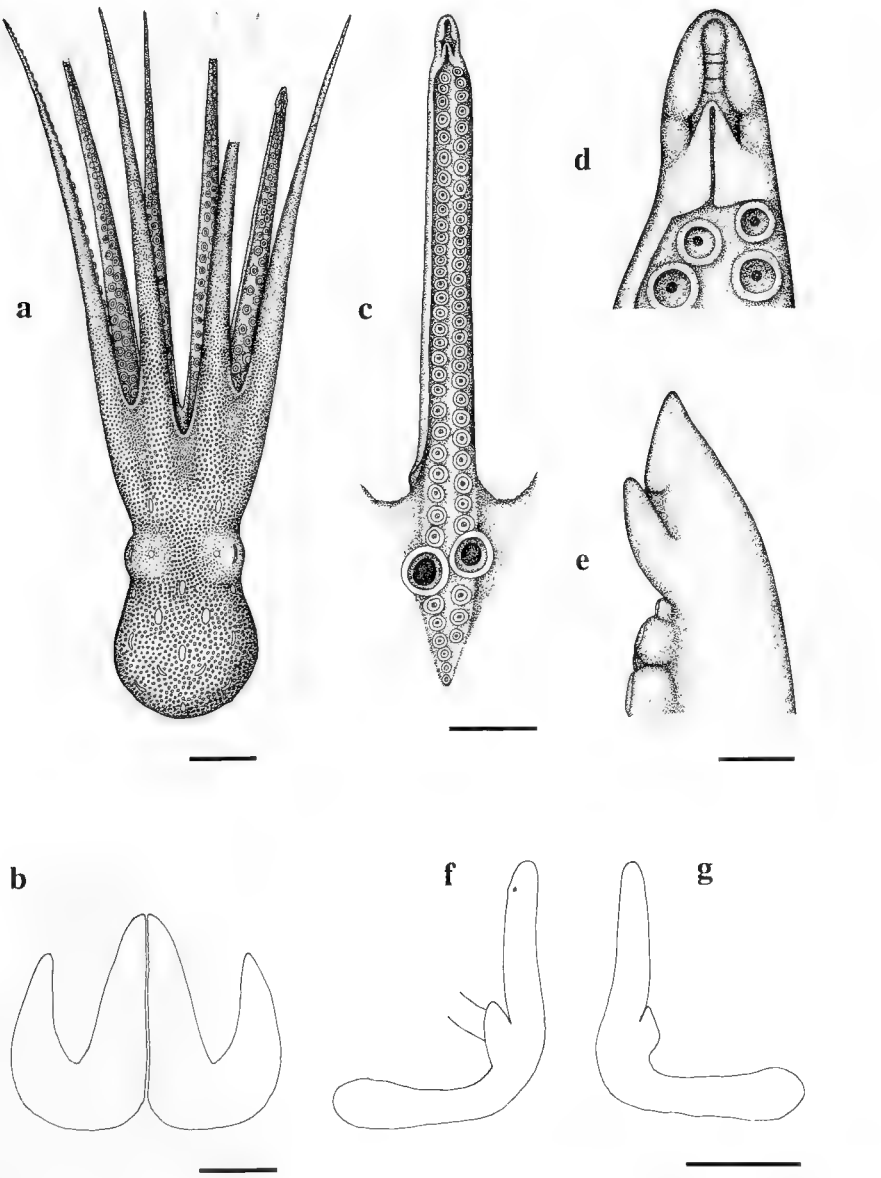


Figure 12. *Octopus campbelli* (Smith): a, dorsal view of BMNH 1902.5.16.2, holotype, M, 27.1 mm ML (scale bar = 10 mm); b, funnel organ (scale bar = 2 mm), c, hectocotylised arm (scale bar = 10 mm), d, dorsal, and e, lateral, detail of hectocotylus (scale bar = 2 mm), of BMNH 1902.5.16.2, holotype, 27.1 mm ML; f, ventral, and g, dorsal, view of penis of AIM AK75675, 34.1 mm ML (scale bar = 5 mm).

Table 5. Material examined: *Octopus berrima* n. sp.

Status	Sex	ML (mm)	Reg. No.	Locality	Date	Depth (m)	Collector
Holotype	1M	58.9	NMV F67132	38°02′S, 145°05′E	10 Oct 1984	—	FV "A.B. Hunter II"
Paratype	1M	36.3	SAM D18775	38°02′S, 145°05′E	25 Sep 1984	—	FV "A.B. Hunter II"
Paratype	1F	56.2	NMV F52514	38°02′S, 145°05′E	29 Jul 1985	—	FV "A.B. Hunter II"
Paratype	1M	63.5	NMV F52513	37°52′S, 148°10′E	5 Jun 1984	25	FV "Sarda"
Paratype	1M	79.6	AM C170006	Refuge Cove, Wilsons Promontory, Vic. [39°02′S, 146°29′E]	7 Feb 1982	—	FV "Sarda"
Other	1F	13.9	NMV F31262	35°23′S, 137°17′E	21 Jan 1971	54	J.E. Watson
Material	1M,1F	15.0-16.3	NMV F25247	Western Port, Vic. [38°22′S, 145°32′E]	6 Mar 1964	—	A. Gilmour
	1F	16.6	NMV F30927	40°56′S, 146°06′E	4 Feb 1981	64-68	FRV "Hai Kung"
	1F	17.8	NMV F52508	D'Entrecasteaux Channel, Tas. [43°15′S, 147°16′E]	2 Oct 1964	—	R.C. Robertson
	1M	21.9	NMV F30860	40°33′S, 144°45′E	4 Feb 1981	68	FRV "Hai Kung"
	1M	23.1	NMV F24450	Mentone, Port Phillip Bay, Vic. [38°00′S, 145°03′E]	26 May 1957	9	NMV
	1M	31.3	NMV F52509	38°11′S, 148°04′E	3 Oct 1983	56	FV "Silver Gull"
	1M	32.6	NMV F52510	38°02′S, 145°05′E	25 Sep 1984	—	FV "A.B. Hunter II"
	1F	43.6	NMV F25245	Western Port, Vic. [38°22′S, 145°32′E]	May 1964	—	A. Gilmour
	1F	45.0	NMV F24492	Black Rock, Port Phillip Bay, Vic. [37°59′S, 145°02′E]	10 Nov 1963	—	P. Egan
	1F	45.2	NMV F52511	38°02′S, 145°05′E	10 Oct 1984	—	FV "A.B. Hunter II"
	1M,2F	46.8-70.6	NMV F31002	39°38′S, 145°05′E	3 Feb 1981	66	FRV "Hai Kung"
	1F	61.8	NMV F67134	38°19′S, 144°43′E	Jun 1992	—	Uni. Melb. Dept. Zool.
	1M	63.4	NMV F67133	37°53′S, 144°57′E	29 Jul 1985	6	RV "Megalopa"
	1M	71.4	NMV F31264	38°03′S, 146°06′E	7 Jun 1978	—	G. Prince
	1F	87.4	NMV F24437	Mt Eliza, Port Phillip Bay, Vic. [38°11′S, 145°04′E]	13 Oct 1957	9	NMV
	1M	105.5	NMV F52515	Stanley, Tas. [40°46′S, 145°18′E]	May 1980	36	Tas. Fish. Dev. Auth.

Table 6. Measurements (mm) and indices of 10 female *Octopus berrima* n. sp. (Imm = immature; S = submature; M = mature; * = arm severed or regenerated).

Museum Reg. No.	NMV F31262	NMV F25247	NMV F30927	NMV F52508	NMV F25245	NMV F24492	NMV F31002	NMV F31002	NMV F52514 (Paratype)	NMV F24437
ML	13.9	16.3	16.6	17.8	43.6	45.0	46.8	50.5	56.2	87.4
StM	Imm	S	Imm	Imm	S	S	S	S	M	M
TL	52.8	52.6	75.8	53.4	177.1	172.4	218.0	261.9	215.4	250.3
MWI	85.6	79.8	84.3	55.1	67.7	60.0	79.5	89.9	88.6	35.5
HWI	68.3	63.8	62.7	51.1	46.3	40.7	42.7	48.3	43.6	26.8
MAI	32.7	39.8	28.3	50.3	33.9	37.1	28.7	25.1	36.6	50.1
ALI: 1	287.8	222.7	313.3	162.9	261.5	210.4	321.2	346.9	226.9	166.2
2	297.8	244.8	265.7*	191.0	289.0	268.4	341.5	377.6	273.0	190.0
3	305.8	251.5	353.0	194.4	295.2	266.7	347.9	397.8	260.1	199.4
4	300.0	235.6	315.1	198.9	278.2	269.8	335.7	378.2	222.6	190.8
AWI	10.8	10.4	7.2	7.3	9.1	7.8	7.5	8.9	7.3	5.3
ASI	7.2–7.9	7.4–9.2	6.0–7.8	3.3–3.9	6.2–7.3	5.6–6.4	6.4–7.3	7.5–8.5	5.7–7.7	4.5–5.4
WDI	25.2	28.0	25.1	32.2	22.2	23.9	22.1	21.0	24.5	25.4
WF	CBEAD	CDBEA	CDBEA	DECBA	DCBEA	DCBEA	DCBEA	DCBEA	CDBAE	CDEBA
GiLC	7	7	8	8	8	8	8	8	8	8
EgLI	—	9.2	—	—	14.0	7.1	4.5	7.1	23.1	12.5
EgWI	—	2.5	—	—	2.8	0.9	0.6	1.0	5.7	3.0
FuLI	50.4	43.6	52.4	39.9	47.7	50.7	49.6	52.1	40.2	31.2
FFuI	27.3	31.3	34.9	32.0	30.3	24.2	28.8	27.7	17.8	18.2
PAI	112.2	91.4	106.6	85.4	101.8	94.2	108.8	108.3	100.7	60.8

Table 7. Measurements (mm) and indices of 10 male *Octopus berrima* n. sp. (Imm = immature; M = mature).

Museum Reg. No.	NMV F25247	NMV F30860	NMV F24450	NMV F52509	NMV F52510	SAM D18775 (Paratype)	NMV F67132 (Holotype)	NMV F52513 (Paratype)	NMV F31264	AM C170006 (Paratype)
ML	15.0	21.9	23.1	31.3	32.6	36.3	58.9	63.5	71.4	79.6
StM	Imm	Imm	Imm	M	M	M	M	M	M	M
TL	48.2	90.7	106.8	124.8	151.8	149.8	273.3	310.7	294.9	361.2
MWI	76.0	78.1	81.0	82.7	92.9	80.4	74.2	68.5	47.8	67.8
HWI	60.0	55.3	52.8	50.8	56.1	47.1	47.0	40.0	32.8	36.1
MAI	43.1	32.5	31.0	34.4	29.2	31.5	28.4	28.0	30.4	30.6
ALI: 1	208.0	273.1	315.2	270.9	302.1	274.9	341.4	329.0	279.6	279.6
2	232.0	305.9	322.1	290.7	338.3	317.4	344.3	357.0	329.1	327.1
3	221.3	307.3	313.4	285.6	342.9	305.5	351.8	353.2	323.9	311.4
4	211.3	284.5	293.9	263.3	309.8	293.7	332.1	340.8	269.9	281.2
AWI	10.0	9.6	7.8	7.8	8.9	8.8	15.8	9.6	6.3	11.3
ASI	8.0–8.7	5.9–8.2	6.9–7.8	7.0–8.6	6.7–8.0	6.9–8.0	10.4–13.1	6.9–9.0	6.2–7.3	8.8–9.4
WDI	24.2	24.1	19.8	23.8	25.2	24.8	24.5	23.8	20.3	23.6
WF	CDBAE	CDBAE	CBDAE	CDBAE	CDBAE	CDBAE	CDBAE	DCB=EA	DCBEA	CDBEA
GiLC	8	7	7	7	8	8	8	8	8	8
HcAI	214.7	245.2	248.1	256.5	293.6	276.6	256.8	231.8	246.1	196.4
OAI	97.0	79.8	79.1	89.8	85.6	90.5	73.0	65.6	76.0	63.0
LLI	10.9	7.3	8.9	13.6	12.7	14.4	12.1	15.5	10.9	13.8
CaLI	20.0	20.5	15.7	20.2	16.4	18.6	15.3	16.2	17.2	16.3
HASC	62	76	79	70	66	74	76	74	78	76
PLI	20.7	14.2	20.3	30.0	27.3	30.3	26.3	30.6	27.0	25.1
SpLI	—	—	—	113.1	125.2	110.7	81.0	77.0	66.4	64.3
SpWI	—	—	—	2.9	2.9	2.6	3.0	2.4	2.5	2.9
SpRI	—	—	—	45.3	40.7	45.6	41.6	50.2	48.4	44.6
FuLI	43.3	50.7	49.4	40.6	43.6	44.4	46.5	43.8	45.7	41.5
FFuI	31.3	30.1	21.2	24.9	19.6	25.1	22.2	34.8	37.7	30.8
PAI	109.3	89.5	110.8	92.3	105.8	101.9	114.1	107.6	89.9	90.8

Table 8. Combined ranges, means and standard deviations of indices of 10 males and 10 females of *Octopus berrima* n. sp.

Index	Range and mean	s.d.(n–1)
MWI	35.5–*73.8*–92.9	14.8
HWI	26.8–*48.6*–68.3	10.7
MAI	25.1–*34.1*–50.3	7.0
ALI 1	135.2–*262.2*–346.9	54.5
2	183.1–*286.8*–377.6	51.3
3	174.2–*292.1*–397.8	58.5
4	177.5–*272.6*–378.2	52.4
AWI	5.3–*8.9*–15.8	2.2
ASI	3.3–*7.3*–13.1	1.7
WDI	19.8–*24.4*–32.2	2.8
HcAI	196.4–*246.6*–293.6	28.0
OAI	63.0–*79.9*–97.0	11.0
LLI	10.9–*13.3*–15.5	1.5
CaLI	15.3–*17.2*–20.2	1.7
PLI	14.2–*25.2*–30.6	5.3
SpLI	56.7–*87.3*–125.2	23.9
SpWI	1.9–*2.6*–3.0	0.3
SpRI	37.5–*43.1*–50.2	3.6
EgLI	11.0–*17.3*–23.1	6.4
EgWI	2.5–*4.2*–5.7	1.7
FuLI	31.2–*45.4*–52.4	5.3
FFuI	17.8–*27.5*–37.7	5.7
PAI	60.8–*99.1*–114.1	12.6

bell Island [52°30′S, 169°E], RV "Southern Cross," Sir G. Newnes, BMNH 1902.5.16.2 (mature male, 27.1 mm ML, preserved in ethyl alcohol).

Other material: New Zealand, Campbell Island, Perseverance Harbour (52°33′S, 169°09′E), 43 m, Galathea-Ekspeditionen, Station 595, 4 Jan 1952, AIM AK75675 (mature male, 34.1 mm ML).

Type locality. New Zealand, Campbell Island [52°30′S, 169°E].

Description. Counts, measurements and indices listed in Table 9. Medium sized animals with firm consistency (Fig. 12a). Mantle saccular, broadly ovoid (MWI 75.7–88.9); mantle wall moderately thin, muscular. Head wide, but narrower than mantle (HWI 56.0–75.3); demarked from mantle by moderate constriction. Eyes large, projecting above surface of head. Funnel large, slender, bluntly tapered (FuLI 38.7–46.5); free for about two-thirds of its length (FFuI 61.9–68.1). Funnel organ W-shaped, outer limbs three-quarters as long as median limbs (Fig. 12b). Mantle aperture moderately wide (PAI 75.1–94.1).

Brachial crown strong, well developed. Arms long (MAI 29.6–33.2) (2.7–3.4 times ML in mature animals); slender (AWI 9.7–11.4), tapering to fine tips. Arm lengths subequal; arm order I=II=III=IV. Suckers biserial, with obvious radial grooves; normal suckers small (ASIn 7.0–10.0), slightly raised from arm surface; 9th and 10th, or 10th and 11th suckers conspicuously enlarged on arms II and III of mature males, highly raised from arm surface (ASIe 13.5–21.4) (Fig. 13).

Web formula B=C=DAE or B=C=DEA; dorsal and ventral sectors shallower. Web shallow (WDI 20.4–22.9); web remnants extend up ventral sides of arms for approximately two-thirds of their length.

Third right arm of males hectocotylised (Figs 12c–e); shorter than its opposite number (OAI 78.8; HcAI 225.2–279.7). Hectocotylised arm with 69–70 suckers; opposite arm with about 150 suckers. Spermatophoral groove well developed, with conspicuous thickening of web membrane. Ligula approximately 6–7% of hectocotylised arm length in mature animals (LLI 6.7–6.8). Ligula conical, with indistinctly marked and shallow groove, and approximately 2–4 poorly defined transverse ridges. Calamus well formed, very long, acutely pointed (CaLI 50.0–51.0).

Gills with 9–10 lamellae on outer demibranch, plus the terminal lamella.

Digestive tract not dissected. Ink sac large, lying embedded on ventral face of digestive gland.

Male reproductive tract not dissected. Penis very long (PLI 47.2–56.3), with 1 very long, curved diverticulum and a second small appendicular diverticulum. Genital aperture subterminal, on right side of penis (Figs 12f, g). Spermatophores relatively long (SpLI 108.5–117.6), slender (SpWI 1.9–2.0), with large, coiled sperm reservoir (SpRI 37.9–39.3).

Female reproductive tract not known.

Integumental sculpture consists of a pattern of fine, rounded and closely set epidermal tubercles; tubercles evenly cover both dorsal and ventral surfaces. Unbranched papillae present in ocular region with 1 large supraocular papilla, and on the dorsal mantle with 4 primary papillae forming diamond arrangement. Ventrolateral integumentary ridge or fold around mantle circumference absent.

No information available on colouring of live animals. Preserved specimens in ethanol uniformly light brown to red brown dorsally, cream to light brown ventrally. Ocelli absent.

Figure 13. *Octopus campbelli* (Smith): oral view of enlarged suckers on lateral arms of AIM AK75675, M, 34.1 mm ML (1 = dorsal arm; 2 = dorsolateral arm; 3 = ventrolateral arm; 4 = ventral arm) (scale bar = 10 mm).

Distribution. New Zealand, Campbell Island (Fig. 13). The species appears to be uncommon, living in subantarctic inshore waters on mud and sand bottom. One depth record exists of 43 m.

O'Shea (1990) also recorded the species from off Timaru, South Island, New Zealand (44°38′S, 172°38′S), in 365 m depth.

Remarks. Smith (1902) originally described *Polypus campbelli* from a specimen collected at Campbell Island during the cruise of RV "Southern Cross" (1898–1900). The description was repeated by Suter (1913), without additional information.

There has since been considerable discussion concerning the taxonomic placement of this species. Robson (1929) provided additional details and illustrations of the type specimen, and placed the species in the genus *Joubinia*. Adam (1938), however, noted that the name *Joubinia* was preoccupied, and proposed the new name, *Robsonella*. An additional complicating factor was Robson's (1929: 145) footnote added in proof, considering this species to be identical to *O. australis*.

The specific name *campbelli* was thus submerged in synonymy with *Robsonella australis* by Benham (1942) and Dell (1952). Subsequently, the systematic characters distinguishing *Robsonella* were reviewed by Pickford (1955), and it was concluded that species previously assigned to the genus *Robsonella* should be reassigned to *Octopus*.

Tait (1982) later recognised *O. campbelli* as a separate and distinct species from *O. australis*.

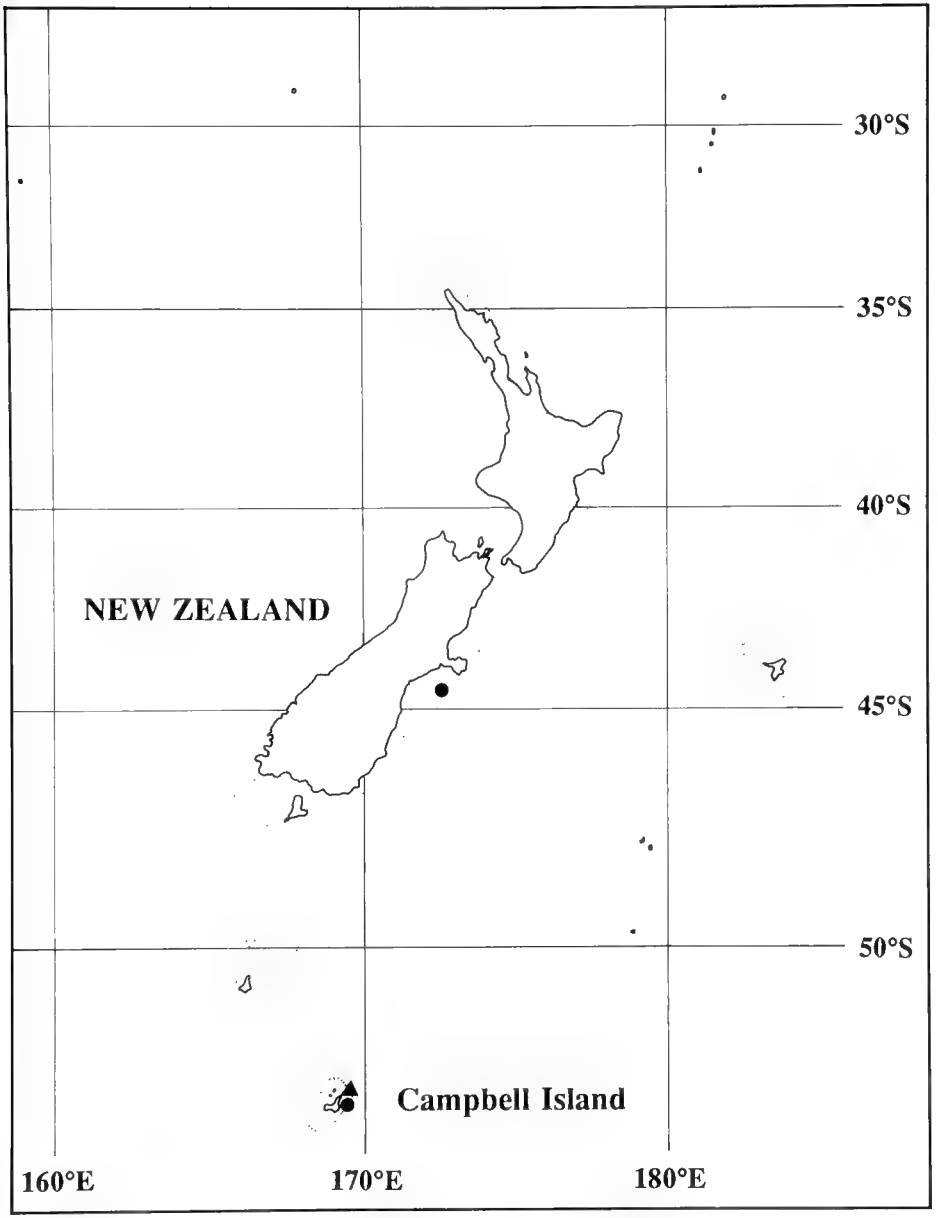


Figure 14. *Octopus campbelli* (Smith): geographical distribution at Campbell Island, New Zealand (▲ = type locality; ● = localities of other material).

Table 9. Measurements (mm) and indices of two male *Octopus campbelli* (Smith, 1902). (M = mature; N.R. = not recorded; * = arm severed or regenerated).

Museum Reg. No.	BMNH 1902.5.16.2	AIM AK75675
ML	27.1	34.1
StM	M	M
TL	122.2	137.2
MWI	88.9	75.7
HWI	75.3	56.0
MAI	29.6	33.2
ALI: 1	325.1	287.4
2	338.0	300.9
3	301.8*	285.9
4	324.0	296.8
AWI	11.4	9.7
ASIn	10.0	7.3
ASIe	21.4	15.8
WDI	22.9	20.4
WF	B=C=DEA	B–C=DAE
GiLC	10	9
HcAI	279.7	225.2
OAI	—	78.8
LLI	6.7	6.8
CaLI	51.0	50.0
HASC	69	70
PLI	47.2	56.3
SpLI	N.R.	117.6
SpWI	N.R.	2.0
SpRI	N.R.	39.3
FuLI	46.5	38.7
FFuI	61.9	68.1
PAI	94.1	75.1

In light of the previous confusion, Tait (1982) and Stranks (1988) recommended a revision of the taxon to determine its systematic status.

O'Shea (1990) described two specimens of *Robsonella campbelli* collected off Timaru, New Zealand, and gave detailed measurements and figures. O'Shea (1990), however, gives little discussion to the taxonomy of the species, and no mention of the systematic decisions of Robson (1929), Pickford (1955) or Tait (1982).

The present redescription is based on examination of the holotype from the BMNH collection, and another specimen of *O. campbelli* from the AIM collection. The few available specimens, and the poor likelihood of a significant number of specimens being collected in the near future, have necessitated the brief form of this redescription. A comprehensive description, particularly of female morphology, must await further material.

O. campbelli can be distinguished from other species of the genus on the basis of a combination of characters: a broadly ovoid mantle; skin with a pattern of fine, rounded and sparsely set tubercles on the dorsum, a large papilla over each eye, but no ventrolateral ridge on the mantle; small but prominent eyes; long, subequal arms (2.7–3.4 times ML in mature animals); large suckers, with two suckers distinctly enlarged on lateral arms of males; a medium sized, stout, conical ligula (6–7% of third right arm length), and a very long calamus; unknown egg size or method of attachment; and 9–10 gill lamellae.

Nothing is known of the biology of the species. The unusual distribution pattern of *O. campbelli* in the shallow waters of subantarctic Campbell Island, as well as in much deeper waters off temperate South Island, New Zealand, may be an example of temperate water submergence.

Discussion

In a recent note, Toll (1991) attempted a revision of *O. australis* and *O. campbelli*, based on one specimen lot from the collection of the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, and on literature accounts. Toll's material comprised four males and two females from Portobello, New Zealand, identified as *O. campbelli*. Unfortunately, very few counts or measurements and no figures were included in the account to enable confirmation of that identification. Working with inadequate material, confusing literature, and without examining relevant types, Toll (1991) concluded that specimens previously identified as *O. australis* could be attributed to either *O. australis* (in the case of Australian specimens) or *O. campbelli* (for New Zealand specimens). Considering results from the present study, Toll's (1991) conclusions are obviously an oversimplification.

Much of the uncertainty about *O. australis* arose from the brief original description, and lack of a mature type specimen of *O. australis*. Many subsequent workers have relied on inadequate published data on the two syntypes of *O. australis* to make taxonomic decisions. Above all, the present study should warn systematists against working purely from published accounts, but instead to rely as far as possible on information gained first hand (especially from

Table 10. Comparison of species in the *Octopus australis* complex.

Species	*O. australis*	*O. berrima*	*O. campbelli*	*O. warringa**
Distribution	Subtropical waters of eastern Australia	Temperate waters of southeastern Australia	Subantarctic waters of New Zealand	Temperate waters of southeastern Australia and New Zealand
Size at Maturity: F M	50–60 mm ML 20–25 mm ML	30–40 mm ML 20–25 mm ML	Unknown ~25 mm ML	>20 mm ML >15 mm ML
Hectocotylus Size and Shape	LLI: 7.5–*12.7*–16.7 CaLI: 15.0–*19.5*–29.4 (medium sized, very robust, bulbous ligula with deep groove and very short calamus)	LLI: 10.9–*13.3*–15.5 CaLI: 15.3–*17.2*–20.2 (medium sized, elongate, conical ligula with deep groove and very short calamus)	LLI: 6.7–6.8 CaLI: 50.0–51.0 (medium sized, robust, conical ligula with shallow groove and very long calamus)	LLI: 6.3–*7.9*–10.2 CaLI: 24.0–*35.7*–50.0 (medium sized, very robust, bulbous ligula with deep groove and short calamus)
Sucker Enlargement	~4–5 suckers enlarged on arms 2 and 3 of males only	No suckers enlarged	2 suckers enlarged on arms 2 and 3 of males	~4–5 suckers enlarged on all arms of males and females
Penis Size and Shape	PLI: 16.6–*18.8*–19.8 (long, simple penis with single coiled diverticulum)	PLI: 14.2–*25.2*–30.6 (long, simple penis with single coiled diverticulum)	PLI: 47.2–56.3 (very long, complex penis, with one long, curved diverticulum and a second smaller diverticulum)	PLI: 15.2–*29.3*–51.9 (very long, simple penis, with a single coiled diverticulum marked with 3 lobes)
Egg Size and Attachment	Large eggs (8–12 mm long) with unknown method of attachment	Large eggs (10–14 mm long) attached singly to substrate	Unknown	Small eggs (2–3 mm long) attached in festoons to substrate
Tubercle Sculpture	Rounded, coarse, closely set tubercles on dorsum. Tubercles on ventral mantle similarly sized, just as prominent, but more scattered	Rounded, very fine, closely set tubercles on dorsum. Tubercles on ventral mantle smaller, less prominent, and more scattered	Rounded, fine, sparsely set tubercles on dorsum. Tubercles on ventral mantle similarly sized, just as prominent, and just as scattered	Rounded, very fine, closely set tubercles on dorsum. Tubercles on ventral mantle smaller, less prominent, and more scattered
Integumentary Ridge on Ventrolateral Mantle	Obvious and continuous ridge around mantle, angled sharply on posterior mantle	Obvious but discontinuous ridge around mantle, roughly straight around mantle posterior	Ridge absent	Ridge absent
Gill Count	7–9	7–8	9–10	6–8

*from Stranks, 1988; 1990

examination of type material as well as an extensive series of comparative specimens).

The complex of previously confused species comprises: *O. australis*, *O. berrima*, *O. campbelli* and *O. warringa*. The species are similar in gross morphology, with broadly ovoid mantles, long and subequal arms, and fine and rounded tubercles on the skin. The four species are otherwise separable on the basis of absolute size, dermal sculpture (particularly the presence or absence of a ventrolateral skin ridge), shape of the hectocotylus and penis, presence or absence of enlarged suckers, and size of eggs (see Table 10). Unfortunately, several of the primary distinguishing characters are sexual, and mature males are easier to identify than females or juveniles.

The four taxa listed are presently considered to belong to the genus *Octopus*. Bearing in mind the relatively fluid state of octopod higher systematics currently, the authors acknowledge that generic re-assignment may be recommended in the future. The current priority has been to rectify species-level taxonomy. *O. australis* and *O. berrima* appear to be species very closely related in terms of morphology, and it is not surprising that they were previously confused. On the other hand, *O. campbelli* and *O. warringa* are very distinctive and would not appear to be as closely related to the former two species.

Each species may be categorised by its reproductive behaviour and associated distribution pattern.

O. australis and *O. berrima* possess relatively large eggs, and in the case of *O. berrima* (and probably also *O. australis*), relatively large juveniles. Therefore juveniles of both species may be assumed to adopt a benthic rather than planktonic existence after hatching (see the classification scheme of Boletzky, 1974; 1977). The geographical distributions of each allopatric species are accordingly limited. *O. australis* is endemic to subtropical waters of southern Queensland and central New South Wales; and, *O. berrima* is endemic to more temperate seas off southern New South Wales and southern Australia.

O. warringa broods relatively small eggs, which hatch out as small juveniles (Stranks, 1988, 1990). Hatchlings of this species probably exist for a period in the plankton before settling out to a benthic habitat. The geographic range for this species may be presumed to be more widespread. Indeed, *O. warringa* is found in temperate waters of both south-eastern Australia and New Zealand (Stranks, 1988, 1990).

Information on size of eggs and juveniles of *O. campbelli* is not available. The species is apparently endemic to subantarctic waters of New Zealand.

Live animal observations, particularly regarding reproductive behaviour or resource partitioning, should reveal other differences between each species.

Acknowledgments

We are grateful to C.C. Lu, Museum of Victoria, for his assistance. We wish to thank C.F.E. Roper, F.G. Hochberg and G.C.B. Poore for comments on the manuscript. We thank the following people for help in making collections available for study: A.B. Stephenson, J. Riley (Auckland Institute and Museum); W.B. Rudman, I. Loch, P.H. Colman (The Australian Museum); F. Naggs (The Natural History Museum); J. Stanisic (Queensland Museum); W. Zeidler, K. Gowlett-Holmes (South Australian Museum). We also thank C. Rowley for assistance with photography. This research was made possible by support grants from the Victorian Institute of Marine Sciences, and the Keith Sutherland Trust (The Australian Museum) to TNS.

References

Adam, W., 1938. *Robsonella* nom. nov. für *Joubinia* Robson, 1929 (Cephalopoda: Octopoda). *Zoologischer Anzeiger* 121(7/8): 223–224.

Benham, W.B., 1942. The octopodous Mollusca of New Zealand. 1. The midget octopus of the coastal waters. *Transactions and Proceedings of the Royal Society of New Zealand* 72(3): 226–236, pls 18, 19.

Berry, S.S., 1918. Report on the Cephalopoda obtained by the F.I.S. "Endeavour" in the Great Australian Bight and other southern Australian localities. *Biological Results of the Fishing Experiments carried on by the F.I.S. "Endeavour," 1909–1914* 4(5): 203–298, pls 59–88.

Boletzky, S.v., 1974. The "larvae" of Cephalopoda: a review. *Thalassia Jugoslavica* 10(1/2): 45–76.

Boletzky, S.v., 1977. Post-hatching behaviour and mode of life in cephalopods. *Symposia of the Zoological Society of London* 38: 557–567.

Brazier, J., 1892. Catalogue of the marine shells of Australia and Tasmania. Part 1. Cephalopoda. *Australian Museum Catalogue* 15: 1–19.

Cotton, B.C., 1939. The Sir Joseph Banks Islands. 4. Mollusca. Part 2. General. *Proceedings of the Royal Society of Victoria* 51(1): 159–176.

Cotton, B.C. and Godfrey, F.K., 1940. *The Mollusca of South Australia. Part 2. Scaphopoda, Cephalopoda, Aplacophora and Crepipoda.* Government Printer: Adelaide. Pp. 317–600.

Dell, R.K., 1952. The recent Cephalopoda of New

Zealand. *Dominion Museum Bulletin* 16: 1–157.

Hoyle, W.E., 1885a. Diagnoses of new species of Cephalopoda collected during the cruise of H.M.S. "Challenger." Part 1. The Octopoda. *Annals and Magazine of Natural History* 5(15): 222–236.

Hoyle, W.E., 1885b. Preliminary report on the Cephalopoda collected during the cruise of H.M.S. "Challenger." Part 1. The Octopoda. *Proceedings of the Royal Society of Edinburgh* 13: 94–114.

Hoyle, W.E., 1886. Report on the Cephalopoda collected by H.M.S. "Challenger" during the years 1873–1876. *Report on the Scientific Results of the Voyage of H.M.S. "Challenger." Zoology* 16(44): 1–245, pls 1–33.

Macpherson, J.H., 1966. Port Phillip Survey, 1957–1963. Mollusca. *Memoirs of the National Museum of Victoria* 27: 201–263.

Macpherson, J.H. and Gabriel, C.J., 1962. *Marine Mollusca of Victoria.* Melbourne University Press: Melbourne. 475 pp.

O'Shea, S.J., 1990. *The Systematics of the New Zealand Octopodidae (Cephalopoda: Octopoda).* Unpublished MSc thesis. University of Auckland, Auckland. 136 pp.

Pickford, G.E., 1955. A revision of the Octopodinae in the collections of the British Museum. *Bulletin of the British Museum (Natural History). Zoology* 3(3): 151–167.

Pritchard, G. and Gatliff, J., 1898. Catalogue of the marine shells of Victoria. Part 1. *Proceedings of the Royal Society of Victoria* 10(2): 236–284.

Robson, G.C., 1929. *A Monograph of the Recent Cephalopoda. Part 1. Octopodinae.* British Museum (Natural History): London. 236 pp., 17 pls.

Roper, C.F.E. and Voss, G.L., 1983. Guidelines for taxonomic descriptions of cephalopod species. *Memoirs of the National Museum of Victoria* 44: 49–63.

Smith, E.A., 1902. Mollusca. Pp. 201–213, pls 24, 25 in: *Reports on the Collections of Natural History made in the Antarctic Regions during the Voyage of the "Southern Cross."* British Museum (Natural History): London.

Stranks, T.N., 1988. *Systematics of the Family Octopodidae (Mollusca: Cephalopoda) of South-Eastern Australia.* Unpublished MSc thesis. University of Melbourne, Victoria. 114 pp.

Stranks, T.N., 1990. Three new species of *Octopus* (Mollusca: Cephalopoda) from south-eastern Australia. *Memoirs of the Museum of Victoria* 50(2): 457–465.

Stranks, T.N., in press. Systematics of the Octopodinae (Mollusca: Cephalopoda) from Australia. *Smithsonian Contributions to Zoology.*

Suter, H., 1913. *Manual of the New Zealand Mollusca.* Government of New Zealand: Wellington. 1120 pp. Atlas of plates, 1915, pls 1–72.

Tait, R.W., 1980. *Aspects of the Ecology and Life History of* Octopus australis *Hoyle, from northern Port Phillip Bay.* Unpublished BSc(Hons.) thesis. Monash University, Victoria. 77 pp.

Tait, R.W., 1982. A taxonomic revision of *Octopus australis* Hoyle, 1885 (Octopodidae: Cephalopoda), with a redescription of the species. *Memoirs of the National Museum of Victoria* 43(1): 15–23, pl. 1.

Toll, R.B., 1991. A note on supposed homonyms of *Octopus australis* Hoyle, 1885, with comments on *Octopus campbelli* Smith, 1902 (Cephalopoda: Octopodinae). *Nautilus* 105(3): 116–117.

Winstanley, R.H., Potter, M.A. and Caton, A.E., 1983. Australian cephalopod resources. *Memoirs of the National Museum of Victoria* 44: 243–253.

CONTENTS